

*Geomorphic and Riparian
Vegetation Assessment
of the
Proposed Napa River Flood Control Project
near the
City of St. Helena, Napa County, California*



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EXECUTIVE SUMMARY

The Napa River flows along the north boundary of the City of St. Helena in northern Napa County. Runoff produced from periodic large storms in the 80 square mile watershed above St. Helena has caused flooding in several developed areas along on the river's flood plain, most notably at the Vineyard Valley Mobile Home Park, the City's Wastewater Treatment Plant, and the Hunt Valley Apartments. Flooding was particularly severe in 1986 and 1995 when many buildings were damaged and residents displaced. The 1995 flood was considered a 100-year peak flood event. Flows on the Napa River typically range from over 20,000 cfs in large peak flow events to less than 5 cfs under summer low flow conditions.

A Draft Comprehensive Flood Study for the City of St. Helena was recently completed by CDM and MBK Engineers in June of 2002 and addressed potential solutions for increasing flood protection. The study identified two alternative plans involving terrace excavation to increase flood capacity in the river, installation of levees and flood walls, and relocation of some flood-prone structures out of the flood plain. Review of the concept plan raised several issues regarding the post project conditions, including the conditions for sustaining native vegetation in new flood plain areas and the resultant channel stability and sediment transport characteristics.

This study is designed to address two specific "Unresolved Issues" described in the Draft Flood Study (Chapter 6.2). One issue is whether or not the terraces will develop as a complex of riparian, upland and wetlands given the hydrology and soils of the site. The other is if the 2-year water surface elevation is appropriate to set the project terrace elevations and to approximate the dominant discharge. A more detailed geomorphic analysis is required to confirm this initial assumption and to address additional questions on the river's impacts to geomorphology (impacts to sediment transport, stream bank stability and overall potential for channel migration) raised by the resource agencies and Friends of the Napa River.

In order to address these issues prior to the preparation of an EIR, Swanson Hydrology & Geomorphology (SH&G) of Santa Cruz prepared the geomorphic assessment and Dennis Odion, riparian ecologist, provided expertise in vegetation ecology.

The focus of the geomorphic study is post-project channel stability and those conditions supportive of the creation and sustenance of riparian habitat within the context of a flood control project. The study involved an analysis of hydraulic forces with and without the project and the frequency of overbank flow, as well as collection of field evidence to document the interaction of sediment transport and geomorphic processes with hydrology and vegetation. The main objectives of the study are to:

- 1) Document geomorphic processes and channel stability related to sediment supply and transport in the project reach and the potential effects of the project;
- 2) Estimate the differences in fine sediment deposition rates on the flood plain under existing conditions and with the project;

- 3) Document the relations between various plant communities and species to summer low flow hydrology in the river and to substrate conditions;
- 4) Develop a recommended conceptual grading plan to achieve sustainable, natural riparian habitat on newly created flood plain surfaces and channel banks with minimized maintenance needs and in conformance with the natural geomorphic processes and hydrology of the Napa River;
- 5) Develop measures to protect large heritage trees on the banks of the Napa River and to replace exotic invasive vegetation with native species; and
- 6) Develop a comparative analysis of the two proposed alternative plans (enhanced minimum alternative, minimum alternative) and with regard to the issues listed above.

The project reach of the Napa River is located between the Sulphur Creek confluence and a point 3150 feet upstream. The Napa River channel is generally 20-25 feet deep, 150 to 250 feet wide in the project reach. The river has been confined by agricultural uses and urban development, including installation of rock slope protection and filling of overflow channel and flood plain areas. The 100-year flood plain, as mapped by FEMA, indicates substantial areas of flooding within the City of St. Helena. This is verified by historical flooding including the 1955, 1986, and 1995 floods.

The Napa River is incised within the older alluvial fan and valley deposits and Stillwater Sciences (2002) estimates that six to eight feet of long term bed degradation has occurred since the turn of the century, likely due to reclamation efforts (filling and straightening), reduction in sediment supply due to water resource dams on tributaries (notably York Creek north of St. Helena) and instream aggregated mining (on Sulphur Creek in St. Helena). The channel pattern has changed little since the mid 1800s, indicating that the Napa River in the project reach has been very stable historically against lateral erosion and meandering.

Under existing conditions, the natural habitats and geomorphic processes of the Napa River are highly confined. In most years, all of the sediment transport and geomorphic work occurs in a limited area of the streambed and channel banks. Only once every ten years on average does flow exceed the banks and spill onto the valley floor. Examination of historical aerial photographs for this study and by Stillwater Sciences (2002) found substantial reduction in overbank flood channels and the width of the riparian corridor and flood plain since the 1940s.

The Enhanced Minimum Plan (EMP) calls for excavation of the terraces above the north and south banks of the Napa River in order to gain enough flood capacity to contain a peak 100-year flood of 21,000 cfs. Levees and floodwalls are proposed along the south side of the river. The area of proposed excavation encompasses over 10 acres along 1,800 linear feet on the north bank and about 8 acres along 1,700 feet of the south bank. The area above the north bank would act as an overflow channel with inlet and outlet widths of 200 feet. The remaining north bank will be preserved with its existing mature riparian vegetation stands. The proposed south bank excavation would also have a 200 foot inlet under a proposed bridge for a new Adams Street Extension, and then open to a wider channel section downstream. Existing bank vegetation is sparse along this reach and new riparian bank vegetation can be established. The proposed overflow channels

would carry Napa River flows starting with the two year flood and contain the peak 100-year flood with up to 3 feet of freeboard. Newly excavated bank areas would be excavated lower in order to increase the area of benches within the river that will be subject to frequent overbank flow and support wetter riparian species.

The excavated terraces are to become riparian habitat with native vegetation plantings. With the plan, vegetation in channel and overbank flood areas would be monitored to keep hydraulic roughness values within tolerances reflected in the assumptions of design hydraulic capacity. A proposed vegetation planting and maintenance plan would address most the hydraulic roughness constraints and recommended maintenance techniques.

The Minimum Plan provides for the same terrace excavation and revegetation as the EMP, however the south bank would be treated much differently. Under the MP, the Adams Street extension would not be constructed and the existing south bank excavation would be reduced. The vegetation along the south bank would be completely removed and fewer mobile homes would be relocated. Hydraulically, the MP would provide the same level of protection.

In order to test the stability of the channel and bedload transport over a range of higher flows a comparison of existing conditions to post project hydraulics was made. Channel stability is defined as a condition where a channel can transport the water discharge and sediment load imposed upon it without greatly changing its width, depth and pattern. This state is often referred to as “dynamic equilibrium” and does not mean that a channel remains in a fixed location. For this reason, it is usually prudent to consider a river channel and its flood plain and terraces as one unit subject to flooding, erosion and sediment deposition.

Field evidence taken in the project reach indicates that the lowest flood flows (in the 500 cfs range) appear capable of scouring coarse sediment from the channel bed on the recession of larger floods. The shear stress produced over a range of peak flows was compared to the shear stress necessary to move the largest particles measured on the streambed in the project reach, or sediment transport “competence” of a particular flow. If the flow cannot move the larger rocks, then they will deposit on the stream bed and may lead to channel aggradation and loss of stability. Channel stability will also be dependent upon bank stability, which appears to be fairly high in the Napa River given the lack of lateral movement in the project reach over last 150 years. The total volume of bedload supplied to the reach can affect channel stability as well.

The project will likely change the sediment transport competence slightly, but not to a significant degree that could defect the project performance or channel stability. With the exception of results at one of the cross sections analyzed, bedload could raise the bed for a short period during the flood. However, the recessional flow would re-sour the streambed and create the low flow and bankfull channel sections.

Two factors that may change in the near future with regard to bedload transport and supply were considered in this analysis. The first is the cessation of instream gravel mining on Sulphur Creek in St. Helena and the restoration of transport continuity to the Napa River by eliminating large sediment trapping pits in the channel. The second is an

effort to remove a water supply dam on York Creek upstream of St. Helena and the project reach. The effect of these changes may be to increase bedload supply to the Napa River and the project reach, although an assessment of these changes is difficult since reactivation of both creeks greatly depends on unknown factors, such as the occurrence of flood events and the sediment transport characteristics of the tributary streams.

In summary, construction of the proposed enhanced minimum plan or minimum plan will probably not result in hydraulic changes significant enough to cause channel stability problems.

Another sediment issue concerns the differences in deposition rates of fine sediments in overbank areas with and without the project. Presently, the existing 100-year flood plain is over 3,000 feet wide and flow begins to go overbank at about the 10-year flood (11,000 cfs). Examination of the USGS flow records reveals only one average daily flow above the 11,000 cfs level, while there are 21 days over 5,000 cfs. This indicates that the duration of overbank flow under current conditions does not last very long compared to the proposed enhanced minimum plan and the time to deposit sediment overbank is limited. The enhanced minimum plan will remove approximately 50 acres from inundation in a 100-year flood, but will add 18 acres that will be flooded once every two years on average. It is also probable that the final grading plan will include vegetated overflow benches within the channel that are below the 5,000 cfs stage to mimic existing bankfull channel conditions and thereby further increase the time overbank flow occurs.

Given these facts, the trapping of suspended sediment will be likely greater with either the EMP or the MP than under existing conditions.

A field reconnaissance investigation of soils and geology in the proposed excavation zones found that the areas are underlain by deep, loamy soils. Some reaches immediately downstream of the project reach have substantial bedrock control lining the low flow channel and at shallow depths below the channel banks. The project reach exhibits deep loamy soils that, when excavated, should be appropriate substrate for riparian vegetation after construction.

A field investigation of riparian and wetland vegetation was undertaken in the project reach in order to determine the suitability of the finished grade MP and EMP for sustaining native riparian vegetation. Data were gathered on the abundance and composition of the vegetation alongside the Napa River in relation to two primary controllers of plant growth, elevation above the summer low water and substrate (soil) grain size. Understanding the distribution of species and vegetation types along gradients of these two variables should make it possible to reasonably predict what vegetation will develop on the terraces and to design, construct and maintain terraces in a manner suitable for targeted plant communities.

Disturbance dynamics such as flooding, sediment deposition and erosion will influence vegetation patterns and maintenance of plantings will be necessary to ensure that the desired and appropriate vegetation develops. In particular, it will be necessary to eliminate and control two pernicious exotic invasive weeds that are common along the Napa River in the project area: Himalaya berry (*Rubus discolor*) and giant reed (*Arundo*

donax). Both species spread vegetatively, producing extensive, impenetrable monocultures, which can largely exclude native vegetation. A third species, periwinkle (*Vinca major*), is slower growing and generally only found near plantings of it. However, it appears to be a similar problem in the study area.

Sixty-seven plant species were found along measured cross sections. 21 non-native weed species were found most were not generally abundant, but a few were.

Valley oak was the most abundant overstory tree in terms of both numbers and basal area. It also preferentially occupied the highest elevations and did not occur on sandy or gravelly substrata that are found closer to the streambed. Coast live oak was similar, and showed an even greater affinity for finer textured soils within the range that was found in the study area. Black walnut is mainly a riparian tree. It occurred over a relatively wide range of elevations above bankfull (about 4 feet), in sandy soils. White alder showed a pattern more readily apparent in the field as an obligate tree because it grows in the active channel, generally below bankfull elevations and on sandy to rocky substrata.

Most of the understory trees were multi-trunked and their diameters were often not measured, so only their presence is shown. Buckeye and elderberry are not riparian obligates and occur in similar positions in ordination space as the oaks. Riparian species like Oregon ash and especially red willow tend to occur much closer to the summer low water elevation, with the willow showing an affinity for coarser soils and the ash occurring over a range of soils. Willows were mainly within the bankfull portion of the stream within the lower 6 feet of the bank.

Young sapling trees that have become established in recent years under present conditions after human-induced geomorphic changes along the Napa River had commenced were measured. A number of valley oak and Oregon ash saplings occur at elevations closer to summer low water, compared to mature specimens. This suggests the adult population of trees may not indicate how close to the summer low flow elevation these species can grow now and in the future.

The two most abundant vines are non-native pest plants, Himalaya berry and periwinkle. Both occur over a wide range of elevations and can form dense monocultures, occupying 100 percent of several plots. The native species that appears to be most displaced by these weeds is California wild grape, which is nonetheless common over a range of elevations and soils. A fourth vine that is also widely distributed within the riparian corridor is pipevine, a species with a very unusual flower and the host plant of the magnificent pipevine Swallowtail butterfly.

Herbaceous species such as *Carex* (*C. obnupta* or *C. barbarae*, a definitive identification of all specimens was not made) and cutgrass were common right at the water's edge, particularly in coarse substrata. The *Carex* species were scattered higher above the river as well. Another *Carex*, *C. nudata*, occurs in the active stream channel, forming remarkable columnar clumps. The most common herbaceous plant away from the river's immediate edge was the introduced bedstraw, *Galium aparine*.

A census of large trees within the Napa River riparian corridor in the project reach was taken in order to document the potential large tree losses due to terrace excavation with the EMP and the MP. The loss of these trees will be offset by new plantings on the immediate banks of the Napa River and on 12-18 acres of newly created excavated terraces. Outside of preserved areas for the MP and EMP, the newly constructed overflow channels will be excavated on the land side of the drip lines of the preserved trees with benches set at an elevation capable of sustaining large trees such as oaks, cottonwoods, walnuts, bay laurel and Buckeye. New excavated inlets and outlets and lower bank areas would be planted to expand shoreline cover of riparian obligate species such as willow, alder and cottonwood as well as native herbaceous (e.g. Carex).

The proposed flood control project on the Napa River near St. Helena represents a significant opportunity to enhance the natural resource values by widening the riparian corridor and restoring natural geomorphic processes. Excavation of about 18 acres of high terrace will create significant opportunities to establish self-sustaining riparian vegetation communities in a corridor over 1,000 feet wide. Areas of large established bank trees will be preserved under the MP and EMP project alternatives. Areas of degraded or denuded banks will be enhanced through excavation of terrace surfaces to elevations capable of supporting a variety of riparian plant communities. This report provides the information necessary to develop a detailed design for excavation of the new surfaces, planting and maintenance operations.

The proposed project addresses some key elements of concern for biological productivity in the Napa River (Stillwater Sciences, 2002), especially for salmonids (steelhead and chinook salmon). A list of potential salmonid life cycle limitations was examined in terms of the potential changes associated with the proposed project. In general, a lack of Large Woody Debris (LWD) in the low flow channel can be addressed as design features to be installed with the project. Other factors, such as shading, connectivity to flood plain surfaces and reduction in substrate mobility, could be improved with the project. The only potential negative impact appears to be the potential to strand migrating fish on the excavated terrace surface. However, this can be addressed in design by ensuring that the overbank areas drain positively towards the river channel on recession flows.

Stillwater Sciences (2002) also investigated the historical changes in the river habitat that may have reduced salmonids' productivity. Stillwater made these comparisons, "*Prior to anthropogenic disturbances in the basin, the Napa River would have had numerous side channels that provided backwater rearing habitat for salmonids. The main stem channel would have connected to its flood plain in most locations, with the flood plain inundated during several storms per year. In contrast, the 1998 aerial photographs depict a simplified river-flood plain system in which the channel has narrowed, incised and largely abandoned its former flood plain, resulting in a loss of backwater rearing habitat.*"

The proposed project (EMP and to a lesser extent MP) has the potential to reverse these changes by restoring flood plain through creation of backwater channels in the proposed terrace excavation and to increase the frequency and duration of overbank flow. The proposed project removes constraints to restoring habitat and a more functional channel flood plain system. Stillwater (2002) was unable to recommend any projects such as

levee setbacks or gravel augmentation, “...*due to expected high social and economic costs of potential main stem restoration activities...*”.

The proposed project has the potential to overcome social and economic costs and provide an example of feasible restoration projects.

In terms of impacts, the proposed project will have to be designed carefully to ensure that the desired vegetation communities are self-sustaining and exotic invasive plants are controlled. This will be accomplished through a rigorous adaptive management plan to replace failed plants and to control undesirable plants.

A comparison of environmental impacts between the minimum plan and the enhanced minimum plan (CDM 2002) was made for the purposes of evaluating impacts and benefits. In terms of channel stability, the minimum plan should have similar hydraulic characteristics as the enhanced minimum plan and therefore it is anticipated that the bedload transport would be similarly affected. The minimum plan has less acreage of overbank flow area and therefore would have less area for sediment deposition. However, it would still have significant area of low flood plain as compared to existing conditions. The impacts to the existing riparian corridor trees are higher with the MP than the EMP because the south bank riparian vegetation is not preserved.

The following are recommendations to be carried out during the detailed design, construction and adaptive management-monitoring program.

- 1) In the grading plan utilize overflow channels to preserve existing large trees and to create a set of benches set at specific elevations to support desired vegetation communities.
- 2) Develop a vegetation plan to address the planting plan and methods for achieving the desired plant community coverage and for controlling undesirable invasive and exotic vegetation.
- 3) Areas in the newly created overbank areas that are to retain low roughness values (Mannings $n = 0.050$ maximum) should focus on establishment of large overstory canopy trees (i.e. cottonwood or oak) with clear understory of grasses and shrubs. Areas dedicated to high hydraulic resistance with dense vegetation should be situated along the banks of the Napa River low flow and bankfull channels.
- 4) Salvage as many native plants from the existing river banks as possible during construction and replant them as quickly as possible at appropriate elevations as described in this report.
- 5) Remove noxious weeds, giant reed (*Arundo donax*), periwinkle (*Vinca major*), and Himalaya berry (*Rubus discolor*) to the maximum extent possible during terrace construction.
- 6) Survey terraces every three months for at least 1-2 years and then every spring and summer after that, and remove any newly establishing weeds.
- 7) Monitor the topography and sediment deposition on overbank areas to determine when maintenance might be needed.

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1. INTRODUCTION

The Napa River flows along the north boundary of the City of St. Helena in northern Napa County. Runoff produced from periodic large storms in the 80 square mile watershed above St. Helena causes flooding in several areas along the river's flood plain, most notably at the Vineyard Valley Mobile Home Park, the City's Wastewater Treatment Plant, and the Hunt Valley Apartments. Flooding was particularly severe in 1986 and 1995, when many residences were damaged; the 1995 flood is considered to be a 100-year peak flood event. Flows on the Napa River range from over 21,000 cfs in the record 1995 peak flow event to less than 5 cfs under summer low flow conditions.

A Draft Comprehensive Flood Study for the City of St. Helena was recently completed by CDM and MBK Engineers in June of 2002 and addressed potential solutions for increasing flood protection. The study identified two alternative plans, the Minimum Plan (MP) and the Enhanced Minimum Plan (EMP) involving terrace excavation to increase flood capacity in the river, installation of levees and flood walls, and relocation of some flood-prone structures out of the flood plain. The excavation of terraces would provide an opportunity for environmental enhancement by expansion of the riparian corridor.

Review of the concept plans for the EMP and MP raised several issues regarding the post-project conditions, including the conditions for sustaining native vegetation in new flood plain areas, and the resultant channel stability and sediment transport characteristics. These factors will influence the overall ecosystem quality and, depending upon how the project is designed and managed, the flood control performance of the project.

This report is designed to address two specific "Unresolved Issues" described in the Draft Flood Study (CDM [2002] Chapter 6.2):

"The Study Team has assumed that terraces will develop as a complex of riparian, upland and wetlands. However, data will need to be collected to determine if the soils and hydrology are compatible with this assumption".

and

"The project terrace elevations have been set at approximately the 2-year water surface elevation. This has been used to approximate the dominant discharge. A more detailed geomorphic analysis is required to confirm this initial assumption. Additional questions on the impacts to geomorphology (impacts to sediment transport, stream bank stability and overall potential for channel migration) of the river have been raised by the resource agencies and Friends of the Napa River."

The Study Team recommended that a geomorphologist and a riparian ecologist be retained to address these issues prior to the preparation of an EIR. As a result, Swanson Hydrology & Geomorphology (SH&G) of Santa Cruz prepared the geomorphic

assessment, and Dennis Odion, riparian ecologist, provided expertise in vegetation ecology.

2. OBJECTIVES

The focus of the geomorphic study is post project channel stability and those conditions supportive of the creation and sustenance of riparian habitat within the context of a flood control project. This involved an analysis of hydraulic forces with and without the project and the frequency of overbank flow, as well as collection of field evidence to document the interaction of sediment transport, geomorphic processes and hydrology with vegetation. The main objectives of the study are to:

- 1) Document geomorphic processes and channel stability related to sediment supply and transport in the project reach and the potential effects of the project;
- 2) Estimate the differences in fine sediment deposition rates on the flood plain under existing conditions and with the project alternatives;
- 3) Document the relations between various plant communities and species to summer low flow hydrology in the river and to substrate conditions;
- 4) Develop a recommended conceptual grading plan to achieve sustainable, natural riparian habitat on newly created flood plain surfaces and channel banks with minimized maintenance needs and in conformance with the natural geomorphic processes and hydrology of the Napa River;
- 5) Develop measures to protect large heritage trees on the banks of the Napa River and to replace exotic invasive vegetation with native species; and
- 6) Develop a comparative analysis of the two proposed alternative plans and existing conditions with regard to the issues listed above.

3. METHODS AND ASSUMPTIONS

Existing data relevant to the hydrology and geomorphology of the Napa River was collected, compiled and reviewed. This included hydrologic data and analyses, geologic information, flood studies, geotechnical studies, sediment transport data, hydraulic geometry, historical land use, and other information documenting the original and present Napa River system. The data was used to develop a site-specific understanding of channel morphology and its relationship with the magnitude and frequency of floods and the occurrence of plant communities. Regional hydrologic and geologic data was used to compare the Napa River to other streams in the region prior to field work.

A similar data collection and review effort was conducted by the riparian ecologist, Dennis Odion PhD, to familiarize himself with existing data, regional plant communities, and vegetation mapping data prior to conducting field work.

Three phases of field work occurred in the late summer and fall of 2002. The first phase was a reconnaissance level survey of the USGS gage at Zinfandel Lane and the project reach. Visual observations were made and a plan for field data collection was formulated.

Phase 1 resulted in the definition of field data needs specific to the project site, located on the Napa River between the Sulphur Creek confluence and the head of the project, 3150 feet upstream. The potential for natural vegetation to occupy the created flood plain and terraces will depend largely on hydrologic factors, such as depth to the summer low water table and flow/fluvial dynamics. Riparian vegetation typically exhibits strong zonation along the gradient from stream to upland and its position along this gradient is predicted largely by depth to, or elevation above, permanent water. Soil aeration will have an effect as well, so sediment deposition and soil particle size are additional data to collect. Given these factors and the resources available, Phase 2 field work involved the collection of vegetation and geomorphic data.

A set of six transects was established and the topography of each was surveyed, along with noting the substrate and the limits of vegetation cover. Vegetation species were separated into categories of overstory trees, understory trees and shrubs, vines, and herbaceous cover. A laser surveying system was used to measure elevations above the stream with a high degree of precision on August 20-21, 2002. Elevations were measured by John Dvorsky and Brian Laurent of SH&G for complimentary geomorphic assessments. Eight cross sections were systematically located along the project reach where terrace excavation is proposed. Cross sections were spaced at fairly regular intervals in representative areas to capture the range of variation present in this stretch of the river. Elevations were gathered at each point where there was a change in topography for each cross section. Vegetation was assessed at these points in a 0.5 x 5 m² area across the contour of the river's banks. The elevation point was the center of each plot and cover of each vascular plant species observed in the plot was visually estimated. An exhaustive search for all plants in each plot could not be undertaken; a few small and inconspicuous species may have been missed. The data are not a rigorous assessment of the riparian flora, but are suitable for the objectives described above. Most plants were identified readily in the field, but some were collected and identified later. Some specimens could not be identified based on the material present.

In addition to vegetation cover in these plots, the elevations at which numerous additional trees were located were determined. To get a reasonable sample size, elevations for trees as far as ~10 m from the cross section were estimated based on where their contour intersected the cross section. Diameter at breast height was measured on a number of trees and visually estimated on others. We did not attempt to establish a cross section through an impenetrable patch of giant reed (*Arundo donax*), but noted that it extended from near the edge of the stream all the way to the top of the bank, indicating this non-native pest plant has the potential to dominate terraces of any dimension within the range being considered.

The cross section and vegetation data were compiled and set into graphical displays for use in developing grading plan and revegetation designs.

For sediment transport analysis, results of pre- and post- hydraulic conditions under various levels of flooding using HEC-RAS modeling provided by MBK Engineers were compared to the observed channel morphology and bed substrates in the project reach. During Phase 2 field work, surface pebble counts were taken within each deposited channel bar within the project reach and particles sizes were compared to the hydraulic forces occurring under a range of floods as calculated by HEC-RAS and to the critical shear stress needed to move larger particles. The results were compared to visual observations of erosional features in the Napa River channel. Sediment supply factors were investigated, including potential changes in management of the tributary streams Sulphur Creek and York Creek, which could increase future sediment delivery to the Napa River.

Historical maps and aerial photographs were collected from the City of St. Helena Public Works Department and local surveyors. These were compared over time to detect changes in channel and flood plain morphology. Remnants of the original natural Napa River flood plain were studied in detail to gain ideas for the grading plan and creation of riparian habitats.

A third phase of field work involved mapping large trees within the riparian corridor of the project reach in order to identify the proposed project's impact to existing vegetation. This was accomplished by measuring the elevation of large trees, noting their species and measuring the diameter at breast height (dbh) and the diameter of drip lines. Each tree's location was then plotted on a recent aerial photograph. We measured diameters at breast height and elevations above low water for the following trees when found above the active channel along the affected banks: valley oak, coast live oak, walnut, Oregon ash, and elderberry. Diameters of multi-trunked trees were measured individually and summed. In general, only trees bigger than about 6 inches dbh were measured, although some smaller oaks were included. All coast live oaks were examined for evidence of Sudden Oak Death, and any symptoms noted. No trees were found to have a combination of all three symptoms that are indicative of incipient mortality (Black ooze, bark beetles, and Hypoxylon fungal fruiting bodies). Black ooze on a number of live oaks did not appear as viscous as is typical for Sudden Oak Death and may be due to something else.

The data was digitized into a GIS file, then plotted. The impacted trees were identified by comparing the map to the proposed enhancement plans.

The final task involved development of a conceptual plan and cross section to depict the proposed enhanced minimum alternative (CDM, 2002) and to provide greater specific detail on how the project will appear in the future.

4. WATERSHED AND PROJECT REACH DESCRIPTION

The Napa River drains a 426 mi² drainage basin from the crest of the interior coast range to San Pablo Bay (**Figure 1**). The project reach is situated in the upper one-third of the basin where runoff collects from 81 mi² of headwaters and the upper valley floor above St. Helena.

The drainage area above the project consists of a gently southward sloping valley floor surrounded by steep mountainous terrain. The mountains to the west are relatively steep and forested with an underlying geology dominated by volcanic rocks. The mountains to the east are less steep with more open terrain and underlain by volcanic and sedimentary rocks.

The City of St. Helena is situated on the valley floor below the mountainous area. The valley floor is dominated by alluvial fans deposited by streams draining from the west, notably Sulphur Creek and York Creek (**Figure 2**). Figure 2 shows that the alluvial fan from Sulphur Creek has pushed the Napa River to the far eastern edge of the valley, indicating that high sediment yields from the mountains to the west have overwhelmed the hydraulic force of the Napa River. The Napa River is a deeply incised channel with surrounding flood plain areas subject to inundation once every 10 years, on average.

5. NAPA RIVER PROJECT REACH AND GEOMORPHOLOGY

The project reach of the Napa River is located between the confluence with Sulphur Creek and a point 3150 feet upstream (**Figure 3**). The Napa River channel is generally 20-25 feet deep, 150 to 250 feet wide in the project reach. The river has been confined by agricultural uses and urban development, including installation of rock slope protection to prevent lateral erosion and filling of overflow channel and flood plain areas to reduce flooding on the valley floor and to create areas for residential development and vineyards. The 100-year flood plain, as mapped by FEMA, indicates substantial areas of flooding within the City of St. Helena. This is verified by many episodes of historical flooding including the 1995 flood, estimated to have a peak flow of 21,000 cubic feet per second (cfs) and thought to represent a once in one hundred year event. Other large damaging floods occurred in 1986 and 1955.

The morphology of the Napa River refers to its geometric characteristics in terms of channel width and depth and flow pattern (or plan form) as viewed from above. In terms of geometry channel width and depth, the Napa River is incised within the older alluvial fan and valley deposits. Stillwater Sciences (2002) estimates that six to eight feet of long term lowering or degradation of the bed of the Napa River has occurred since the turn of the century, likely due to reclamation efforts (filling and straightening), reduction in sediment supply due to water resource dams on tributaries (notably York Creek north of St. Helena) and instream aggregated mining (on Sulphur Creek in St. Helena) (**Figure 4**). The channel pattern in the project reach has changed little since the mid 1800s (**Figure 5**), indicating that the Napa River in the project reach has been very stable historically against lateral erosion and meandering.

Figure 6 shows a picture of the Napa River channel in the upper project reach. The channel has a gravel bed with alternating bar forms that are subject to intensive scour during floods. This area generally has a mature and dense riparian forest canopy with overstory and understory trees, shrubs, vines, sedges and grasses. The enclosed overstory canopy has effectively shaded out scrubby willow growth that is typical of channel reaches exposed to sunlight.

Figure 7 shows a photo of the lower project reach just upstream of the Sulphur Creek confluence along the Vineyard Valley Mobile Home Park. This reach has more open sunlight and denser growth on the streambed, with sparser vegetation on the banks and fewer overstory canopy trees. The streambed has predominately gravel sizes.

Under existing conditions, the natural habitats and geomorphic processes of the Napa River are highly confined. In most years, all of the sediment transport and geomorphic process work occurs in a limited area of the streambed and channel banks. Only rarely does flow exceed the banks and reach the valley floor. Once large floods have passed, the valley floor areas are reclaimed to agricultural or urban uses. Examination of historical aerial photographs for this study and by Stillwater Sciences (2002) found substantial reduction in overbank flood channels and the width of the riparian corridor and flood plain. **Figure 8** shows a reach upstream of St. Helena in 1940, where multiple flood channels were lined with large trees. These overflow channels may have been the main channel at some time, however it is clear that the riparian ecosystem of the Napa River extended well beyond its flood channel and that considerable reclamation work has narrowed it to its current extent. The same historic encroachment appears in the project reach where prominent overflow channels occur within 1,000 feet of the present river bank. Recent aerial photographs (**Figure 3**) show one channel extending into the floodwall on the west side of the Vineyard Valley Mobile Home Park. The narrowing of the channel by filling would partially explain the 6 to 8 feet of historical channel degradation documented in the Napa River [**Figure 4** and Stillwater Sciences (2002)].

6. PROPOSED PROJECT

Figure 3 shows the proposed “enhanced minimum plan” alternative in plan view. This geomorphic and vegetation assessment first considers the enhancement minimum plan (EMP) in detail and then examines the differences in impacts and benefits to the “minimum plan”. These two alternatives and the existing conditions “no-action” plan are presently under environmental review.

The EMP calls for excavation of the terraces above the north and south banks of the Napa River in order to gain enough flood capacity to contain a peak 100-year flood of 21,000 cfs. Levees and floodwalls are proposed along the south side of the river to protect a reconfigured Vineyard Valley Mobile Home Park and other residential developments. The area of proposed excavation encompasses over 10 acres along 1,800 linear feet on the north bank and about 8 acres along 1,700 feet of the south bank. The new overflow area above the north bank would act as an overflow channel with a 200-foot wide inlet and outlet while preserving the remaining north bank; this will minimize the number of trees requiring removal. The proposed south bank excavation would also have a 200 foot inlet under a proposed bridge for a new Adams Street Extension, and then open to a wider channel section downstream in the area of the Vineyard Valley Mobile Home Park. Existing bank vegetation is sparse along this reach and new riparian bank vegetation can be established. The proposed overflow channels would carry Napa River flows starting with the two year flood and contain the peak 100-year flood with up to 3 feet of freeboard. Newly excavated bank areas would be excavated lower in order to increase the area of benches within the river that will be subject to frequent overbank flow and support wetter riparian species.

The excavated terraces are to become riparian habitat with native vegetation plantings. With the plan, vegetation in channel and overbank flood areas must be kept within tolerances of the hydraulic roughness values reflected in the modeling assumptions used to calculate hydraulic capacity. A proposed vegetation planting and maintenance plan would address the hydraulic roughness constraints and recommended maintenance techniques. The original hydraulic modeling used to define the project alternatives assumed a generally flat excavation at the two-year flood level, with 2 horizontal to 1 vertical (2H:1V) graded slopes along the edges of excavation and along tree drip lines.

Some channel bank protection may be needed to prevent lateral erosion along areas close to the proposed flood wall and levees. These will likely be bioengineered structures that utilize rock rip rap and native vegetation plantings. Rip rap would be placed as an irregular shoreline with vegetation plantings where protection is located at the low water channel.

7. CHANNEL STABILITY AND SEDIMENT TRANSPORT

Channel stability can be defined as the condition where a channel can transport the water discharge and sediment load imposed upon it without greatly changing its width, depth and pattern. This state is often referred to as “dynamic equilibrium” where the balance of water discharge and sediment load is reflected in the width and depth of the channel, its gradient and plan form. A state of dynamic equilibrium does not mean that a channel remains in a fixed location, however. A channel can meander across a valley floor through lateral erosion of its banks, yet by sediment deposition of bars and new flood plain, maintain a mean width, depth and plan form. For this reason, it is usually prudent to consider a river channel and its flood plain and terraces as one unit subject to flooding, erosion and sediment deposition.

The ability of a channel to transport the sediment load imposed upon it is proportional to the hydraulic force generated by a given flood. Hydraulically, flow exerts a shear stress on the channel boundaries that is proportional to the depth and slope of the water surface during a given flood. In general, the sediment supplied to the reach increases as flows increase but at the same time the hydraulic force increases to offset increased supply. Often a channel can be filled or partially filled with sediment on a rising limb and peak of a flood, then subsequently scour itself out during the flood recession.

Sediment loads in rivers and streams are categorized by mean grain size diameter and mode of transport. The finest soluble constituents and clays are carried as “wash load” and once entrained are often washed out of the given stream to receiving waters, in this case San Pablo Bay at the Carquinez Straights. “Suspended sediment load” consists of fine particles of clays up through silts and fine sand, which are transported by suspension in the water column. “Bedload” consists of the largest particles in transport, from sands to large boulders. It is the bedload transport that can be affected by slight changes in hydraulic forces and can consume considerable space in the channel. Bedload therefore can have the greatest impacts on channel stability and merits attention with regard to the proposed project.

In order to assess the sediment transport of the Napa River in its present condition, we examined the present channel, measure streambed sediment sizes and examine evidence of channel formation. When assessing a channel, it is useful to identify three stages or separate channels within the river. The smallest is the “low flow” channel, which carries flow over 99 percent of the time and contains most of the aquatic habitat in a given stream system. The next channel is often termed the “bankfull” channel and reflects those flows that move sediment and occur often enough to influence the channel width and shape in a fundamental way. It is also concurrent with the elevation at which a new flood plain is formed; flood plain in geomorphology is defined as a low flat area or bench occurring adjacent to the channel and receiving fine sediment deposition in the present climate. The bankfull channel is also concurrent with the flow that carries the most sediment over time, which is a reason why bankfull flow has a great influence on channel form. The largest channel is often called the “flood” channel and contains flows up to the point where channel capacity is exceeded and spills out onto the valley floor (or flat). This channel is bounded by terraces, which in geomorphology are defined as “abandoned” flood plain surfaces by virtue of the fact that the channel bed has incised and these terraces are no longer subject to frequent flooding and fine sediment deposition. The incision of a channel into a valley floor can be caused by climatic change and/or by human land use (i.e. channel straightening, reduction in sediment supply, levee construction, flow confinement, urbanization).

Figure 9 shows the Napa River at the USGS stream gage Napa River near St. Helena, which is located several miles below the project site. The **Figure 7** photo shows SH&G geomorphologist John Dvorsky situated next to a staff plate, or measuring stick, used to reference the depth of flow to discharge (cubic feet per second) past the gage. His feet are at the elevation of a prominent bench on the other side of the low flow channel, while his head appears at the stage of a 2-year flood of 5,000 cfs. **Appendix B** is the cross section data from USGS flow measurements. Although average regional channel geometry relationships of the 1.5-year flood show wider (60 feet) and shallower channel size (4.5 feet) for the drainage area above the gage (81.4 mi²) (Leopold, 1994; Rosgen, 1994)¹, it is clear that shallow bedrock and perhaps the flashy nature of the upper Napa River result in a reduced bankfull channel and a lower flood plain bench. This may also be the result of historic channel bed incision, since 6 to 8 feet would correspond more closely with a wider and shallower channel. Some researchers assert that bankfull channel is ill defined (Williams, 1986) and might be more highly variable due to a lack of consistency in definition and researcher’s field judgment.

Field bankfull channel indicators measured as a part of this study indicate a channel on the average of 60 feet wide and 4.7 feet deep. **Figure 10** shows the location of the cross sections and **Figure 11** shows a tabular and plot summary of the bankfull geometry and profile survey conducted by SH&G in 2002; channel cross section plots are located in **Appendix A** at the end of the document. **Figure 12** shows an example of a bankfull indicator and the zones subject to scour and erosion versus those areas subject to sediment deposition and flood plain formation.

¹ It is interesting to note that the data base values used for Leopold’s average regional plot show the Napa River at St. Helena gage with a 1.5 year flood of 4,800 cfs with a 100-foot width, 7.0 foot depth and 8.9 feet per second velocity. These values are much higher than the average curves and are strictly based upon stream gaging data.

Thus, based upon field evidence, the lowest flood flows (in the 500 cfs range) appear capable of scouring the bankfull channel on the recession of larger floods. In order to test the stability of the channel and bedload transport over a range of higher flows a comparison of existing conditions to post project hydraulics was made.

The shear stress produced over a range of peak flows was compared to the shear stress necessary to move the largest particles measured on the streambed in the project reach. This analysis is a measure of the sediment transport “competence”, or the largest particles moved in a particular flow. If the flow cannot move the larger rocks, then they will deposit on the stream bed. If the deposits accumulate and aggrade the stream bed, the channel could fill and stability would be lost. Channel stability also depends upon bank stability, which appears to be fairly high in the Napa River given the lack of lateral movement over the last 150 years. The total volume of bedload supplied to the reach, not just that of the larger sized particles, can affect channel stability as well. The volume of sediment transported is related to the sediment transport capacity of the river over a range of flows, and the stability of the channel will depend upon sediment supply factors discussed below.

A U.S. Army Corps of Engineers computer simulation model HEC-RAS prepared and transmitted to SH&G by MBK Engineers was used to generate computed shear stress of a range of flows at each of the 8 SH&G cross sections where the streambed particle sizes were measured by surface pebble count (**Figure 13a**). The HEC-RAS model can be changed to show hydraulic conditions with and without the proposed terrace excavation project and this is shown in **Figure 13b**. **Figures 14a through 14d** show the computed shear stress for a range of peak floods.

The proposed project could reduce or increase shear stress and thus sediment transport. **Figures 15a through 15g** show with and without project conditions for a range of flows at 7 of the 8 SH&G cross sections. Each plot shows changes in mean flow velocity in the channel, the changes in shear stress, and the critical shear required to move the 84th percentile largest particle as measured at the SH&G cross section. These results are discussed below.

Cross section 1 (**Figure 15a**) is located at the upstream head of the project and shows a significant increase in shear stress above the 10-year flood level due to a steepened water surface slope. This is likely the result of flow area expansion onto the proposed excavated terrace on the north side of the channel. All shear stresses are well above the critical shear of the bed particle D_{84} and therefore there should be an increase in the size transported. The EMP flow velocities are still within the range of 5 to 6 feet per second, probably similar to the range experienced by the existing stable channel.

Cross section 2 (**Figure 15b**) also shows an increase in mean shear stress with the project. This would represent little change in transport competence as all values were already above the critical value needed to move the D_{84} 62 mm diameter particle. Mean flow velocity in the channel shows a small increase that is within the same range as existing conditions.

Cross section 3 (**Figure 15c**) shows a significant reduction in shear stress above the 2 year flood into ranges below the critical shear stress needed to transport the relatively large D_{84} size of 55 mm. Flows of 5,000 cfs or less exceed the critical shear indicating that recessional flows are still effective in scouring bedload; this would be consistent with field observations of the bankfull channel described above and shown in **Figure 12**. Flow velocity is reduced by at most 0.4 feet per second, which is not deemed to be significant.

Cross section 4 (**Figure 15d**) shows shear stress decreases from all above critical shear to all flows below critical shear. This is the only cross section that shows all flows under critical shear. All cross sections downstream and upstream show shear stress values over critical shear at the lower end of flood discharge range and the re-incision of the channel bed appears throughout the project reach. For this reason, it is likely that transport of larger particles would occur below 5,000 cfs modeled flow.²

Cross sections 5, 7 and 8 all show similar results (**Figures 15e through 15g**). Here shear stress at lower floods is adequate to re-scour the channel, but at floods above 10-year, shear stress declines below critical shear due to backwater from downstream. This would be consistent with field observations. The amount of change between existing and proposed conditions does not appear to be significant enough to warrant concern that the channel will aggrade.

The preceding assessment indicates that the project will likely change the sediment transport competence slightly, but not to a significant degree that could defect the project performance or channel stability. With the exception of results at cross section 4, each cross section shows that bedload could raise the bed for a short period during the flood. However, the recessional flow would re-sour the streambed and create the low flow and bankfull channel sections.

The other aspect of sediment transport to consider is the potential changes in sediment transport capacity, or the volume of sediment transported over the same range of floods. This factor is more difficult to compute reliably as there is no data to substantiate the volume of sediment supplied to the reach over a range of floods or the grain size distribution of sediment in transport at various flows. However, there is abundant evidence of 6 to 8 feet of channel bed degradation, indicating that sediment transport capacity (hydraulic force of floods) has greatly exceeded bedload sediment supply. With the incoming flows virtually unaffected by the project and indications that sediment transport competence will be little changed per analysis above, it can be safely concluded that sediment transport capacity will not be significantly altered.

Two factors that may change in the near future with regard to bedload transport and supply were considered in this analysis. The first is the cessation of instream gravel mining on Sulphur Creek in St. Helena and the restoration of transport continuity to the Napa River by eliminating large sediment trapping pits in the channel. The second is an effort to remove a water supply dam on York Creek upstream of St. Helena and the project reach. This may allow bedload to move downstream to the Napa River for the

² Note that the HEC-RAS model for the project reach does not provide reliable results for smaller flows and was therefore not used for flows less than 5,000 cfs.

first time in decades. The effect of these changes could be to increase bedload supply to the project reach. New bedload reaching the Napa River from York Creek would be transported through the project reach. New bedload delivered by Sulphur Creek would have to be flushed from its confluence with the Napa River.

An assessment of these changes is difficult since reactivation of both creeks greatly depends on unknown factors, such as the occurrence of flood events and the sediment transport characteristics of the tributary streams. However, both of these creeks emanate from the mountains to the west and move onto the alluvial fan, before flowing into the Napa River. Once alluvial fan processes become re-established, the stream could deposit bedload in the tributary channel until it fills with coarse sediments. It would then avulse abruptly to a different flow path on the fan surface before reaching the Napa River. If, on the other hand, bedload were to be transported through the tributary streams to the Napa River, historical indications of 6 to 8 feet of channel bed degradation imply that the incised channel now has more hydraulic force than it had prior to damming and mining on the tributaries. Considering that the channel plan form has not changed in the project reach for over 150 years (**Figure 5**), it is unlikely that restoring the supply once again would cause a significant problem to the stability of the project. If the supply were more than the channel could transport, then one would expect episodes of the channel filling with bedload followed by avulsion, but that does not appear to be the case in the project reach. In sum the Napa River appears sediment starved, and its recent history of bed degradation appears to have been caused by both reductions in sediment supply and the reclamation practices of filling banks and constructing levees.

In summary, construction of the proposed enhanced minimum plan would not result in hydraulic changes significant enough to cause channel stability problems.

8. FINE SEDIMENT DEPOSITION

Another sediment issue concerns the differences in deposition rates of fine sediments in overbank areas with and without the project. Presently, the existing 100-year flood plain is over 3,000 feet wide and flow begins to go overbank at about the 10-year flood (11,000 cfs). Examination of the USGS flow records reveals only one average daily flow above the 11,000 cfs level, while there are 21 days over 5,000 cfs. This indicates that the duration of overbank flow under current conditions does not last very long compared to its duration under the proposed enhanced minimum plan. The enhanced minimum plan will remove approximately 50 acres from inundation in a 100-year flood, but will add 18 acres, which will be flooded once every two years on average.

In order to develop a detailed estimate of the differences of fine sedimentation rates, several pieces of information are needed. First, the volume of water in the overbank areas must be known for various flood events, along with the mean velocity and suspended sediment load concentration and grain size distributions. An in-depth analysis requires more hourly stream flow and sediment data than is presently available. The USGS publishes only mean daily and peak flows, which are not precise enough to capture the amount of time (in hours) flow is out of bank under existing conditions. Once the volumes of overbank flow are known between existing conditions and the proposed conditions, a uniform estimate of deposition rates can be assessed by comparing grain

sizes in transport and settling velocity of particles. Since it would take a substantial amount of time to acquire this data, use of the daily data will be used in the interim.

As stated above, the stream flow record shows that only one day on record exceeded 11,000 cfs discharge (14,500 cfs on February 17, 1986), whereas over 21 days exceeded 5,000 cfs. It is probable that the final grading plan will include low benches below the 5,000 cfs stage to mimic existing bankfull channel conditions and thereby further increase the time overbank flow occurs. Given this fact alone, the trapping of suspended sediment will be greater with the project and terraces than under existing conditions. In a 100-year flood, the inundation is up to 1,500 ft wider under existing conditions, however the new benches will be inundated longer than occurs under existing conditions. In terms of exposure to overbank flow, the proposed enhanced minimum plan will greatly exceed existing conditions.

In addition to the frequency and duration of flooding, the following observations provide insight to the fine sediment issue:

- Observations made during the 1986 and 1995 floods (the latter deemed to be a 100-year peak flood event) at the Vineyard Valley Mobile Home Park indicate that mud deposits amounted to about an inch (David Dickson (MIG) and Joe Countryman (MBK Engineers) personal communication 2002). This suggests that the concentration of fine sediments in overbank flow is low, as is the sedimentation rate.
- Stillwater Sciences (2002) in a review of limiting factors for salmonids production in the Napa River watershed, found that turbidity levels after small floods were below the threshold of impact to aquatic life, and therefore not deemed a significant problem for feeding.
- Stillwater Sciences concluded that fine sediment deposited on the river bed might be a widespread problem for spawning gravel suitability for chinook salmon and steelhead on the main stem Napa River. The overall significance of this in terms of limiting factors for salmonids production is not well known as tributaries account for most of the production. There is no discussion in Stillwater (2002) on the importance of overbank flow to filter fine sediments and reduce stream bed sedimentation.

9. RIPARIAN VEGETATION AND CHANNEL GEOMORPHOLOGY

9.1. Introduction

Alternatives that involve excavating streamside terraces to reduce flooding in the City of St. Helena from the Napa River are presently being considered. An unresolved issue with regard to the terraces is, what vegetation will they support? In order to answer this, a field investigation of riparian and wetland vegetation was undertaken in the project reach. Data were gathered on the abundance and composition of the vegetation alongside the Napa River in relation to two primary controllers of plant growth, elevation above the summer low water and substrate (soil) grain size. Understanding the distribution of species and vegetation types along gradients of these two variables should make it

possible to reasonably predict what vegetation will develop on the terraces and to design, construct and maintain terraces in a manner suitable for targeted plant communities.

Disturbance dynamics such as flooding, sediment deposition and erosion will influence vegetation patterns, and maintenance of plantings will be necessary to ensure that the desired and appropriate vegetation develops. In particular, it will be necessary to eliminate and control two pernicious exotic invasive weeds that are common along the project area: Himalaya berry (*Rubus discolor*) and giant reed (*Arundo donax*). Both species spread vegetatively, producing extensive, impenetrable monocultures, which can largely exclude native vegetation. A third species, periwinkle (*Vinca major*), is slower growing and generally only found near plantings of itself. However, it appears to be a problem in the study area.

Most vegetation maintenance activities, such as pruning and excavation of excess sediments to meet hydraulic constraints, can be designed to mimic natural flood disturbance and natural plant community succession. As discussed above, the natural morphology of the Napa River and its flood plain included the formation and maintenance of large tree-lined flood overflow channels that appear to have scoured frequently enough to maintain an open channel. The final specific vegetation planting and maintenance plan will be developed during the planning engineering and design and will meet objectives listed below in the recommendations section.

9.2. Results

Sixty-seven plant species were found along the cross sections (**Table 1**). There were 21 non-native weeds. These were generally not abundant, but a few were very much so, as the figures will illustrate. Dominant species and their environmental relationships are described below.

Table 1. Vascular Plant Species Found Along Cross Sections of the Napa River near St. Helena, August 2002

Nomenclature follows Hickman (ed.) 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley, Ca.

***indicates non-native species**

	Common name	Abundance
Trees		
<i>Acer macrophyllum</i>	big leaf maple	Uncommon
<i>Aesculus californica</i>	California buckeye	Common
<i>Alnus rhombifolia</i>	white alder	Common
<i>Fraxinus latifolia</i>	Oregon ash	Scattered
<i>Juglans californica</i> (var.hindsii)	Black walnut	Common
<i>Juglans regia</i>	English walnut	Uncommon
<i>Quercus agrifolia</i>	coast live oak	Common

<i>Quercus lobata</i>	valley oak	Common
<i>Salix laevigata</i>	red willow	Common
<i>Sambucus mexicana</i>	elderberry	Scattered

Shrubs

<i>Arundo donax</i>	giant reed	Scattered
<i>Mentha sp</i>	mint	Scattered
<i>Populus fremontii</i>	Fremont cottonwood	Uncommon
<i>Prunus subcordata</i>	Sierra plum	Uncommon
<i>Rosa californica</i>	wild rose	Uncommon
<i>Salix hindsiana</i>	sand-bar willow	Scattered
<i>Salix lasiolepis</i>	Arroyo willow	Uncommon
<i>Salix lucida ssp. lasiandra</i>	shining willow	Uncommon
<i>Symphoricarpos albus</i>	common snowberry	Common

Vines

<i>Aristolochia californica</i>	pipevine	Common
<i>Cornus glabrata</i>	brown dogwood	Uncommon
<i>Marah fabaceous</i>	wild cucumber	Uncommon
<i>Rubus discolor*</i>	Himalaya berry	Common
<i>Toxicodendron diversilobum</i>	poison oak	Scattered
<i>Vinca major*</i>	periwinkle	Common
<i>Vitis californicus</i>	California wild grape	Common

Terrestrial herbs and grasses

<i>Agrostis spp.*</i>	bent grass	Common
<i>Artemisia douglasiana</i>	mugwort	Scattered
<i>Avena barbata*</i>	wild oak	Uncommon
<i>Bacopa eisenii</i>	water hyssop	Common
<i>Bromus diandrus*</i>	rip-gut brome	Uncommon
<i>Carduus pycnocephalus*</i>	Italian thistle	Scattered
<i>Carex obnupta/barbarae</i>	sedge	Common
<i>Chenopodium botrys</i>	goosefoot	Common
<i>Convolvulus arvensis*</i>	bindweed	Uncommon
<i>Cortaderia sp.*</i>	pampas grass	Uncommon
<i>Cynosaurus echinatus*</i>	dog-tail grass	Uncommon
<i>Cyperus eragrostis</i>	nutgrass	Common
<i>Daucus carota*</i>	carrot	Scattered
<i>Epilobium brachycarpum</i>	willow herb	Common
<i>Epilobium ciliatum</i>		Uncommon

<i>Equisetum telmateia</i>	horsetail	Scattered
<i>Foeniculum vulgare</i> *	fennel	Uncommon
<i>Galium aparine</i> *	bedstraw	Common
<i>Gnaphalium luteo-album</i> *	fragrant everlasting	Uncommon
<i>Hirschfeldia incana</i> *	field mustard	Uncommon
<i>Hordeum murinum</i> *	foxtail	Uncommon
<i>Juncus sp</i>	rush	Uncommon
<i>Lactuca serriola</i> *	wild lettuce	Uncommon
<i>Leersia oryzoides</i>	cut grass	Common
<i>Lemus triticoides</i>		Uncommon
<i>Melilotus albus</i> *	white sweet clover	Scattered
<i>Paspalum urvellei</i>	dallis grass	Uncommon
<i>Piptatherum milacea</i>	smilo grass	Scattered
<i>Polypogon monspeliensis</i> *	rabbit's foot grass	Uncommon
<i>Rhaphanus sativa</i> *	wild radish	Uncommon
<i>Rumex sp.</i> *	dock	Uncommon
<i>Scrophularia californica</i>	figwort	Uncommon
<i>Stachys ajugoides</i>	hedge nettle	Uncommon
<i>Torilis nodosa</i> *	wild parsley	Scattered
<i>Xanthium strumarium</i>	cockle bur	Scattered

Aquatic herbs and grasses

<i>Alisma plantago-aquatica</i>	water plantain	Uncommon
<i>Carex nudata</i>	Dudley's sedge	Scattered
<i>Ludwigia peploides</i>	water primrose	Scattered
<i>Polygonum amphibium</i>	water smartweed	Scattered
<i>Scirpus fluviatilis</i>	river bulrush	Uncommon
<i>Typha latifolia</i>	cattail	Uncommon

Figure 16 shows a generalized plot of different vegetation plant communities within a typical cross section in the project reach. In **Figures 17-22**, individual species are arranged where they were found along gradients of soil texture (x axis) and elevation above summer low water (y axis). These two dimensional diagrams are called ordinations. They illustrate how each species is unique in its habitat preference. It is important to point out that there are other variables that dictate the habitat preferences of species, including fluvial disturbance and subsequent community succession.

Figure 17 is an ordination diagram showing overstory trees. The diameter of each tree is indicated by the size of the circle. Valley oak was the most abundant overstory tree in terms of both numbers and basal area. It also preferentially occupied the highest elevations and did not occur on sandy or gravelly substrata. Coast live oak was similar,

and showed an even greater affinity for finer textured soils within the range that was found in the study area. Neither oak is a riparian obligate, however, valley oaks generally occur where their roots can tap into permanent, or nearly so, groundwater. Black walnut is mainly a riparian tree. It occurred over a relatively wide range of elevations above bankfull (about 4 feet), in sandy soils. White alder showed a pattern more readily apparent in the field. Wherever this widespread riparian obligate tree occurs, it grows in the active channel, generally below bankfull elevations and on sandy to rocky substrata. Only two cottonwoods were found along the study reach. This species appears to have similar habitat preferences as alder, but more data are needed. From experience, cottonwoods tend to grow in finer textured soils and somewhat less in the active stream channel compared to alder.

Figure 18 shows understory trees. Most of these were multi-trunked and their diameters were often not obtained, so only their presence is shown. Buckeye and elderberry, like the oaks, are not riparian obligates and occur in similar positions in ordination space as the oaks. Riparian species like Oregon ash and red willow tend to occur much closer to low water elevation, with the ash occurring over a range of soils and the willow showing an affinity for rather coarse soils. Willows were mainly within the bankfull portion of the stream, though a few occurred well above this.

Saplings are plotted in **Figure 19**. These < 1" diameter at breast height, young trees became established in recent years after downcutting and other human-induced geomorphic changes along the Napa River had commenced. A number of valley oak and Oregon ash saplings occur at elevations closer to low water, compared to mature specimens. This suggests the adult population of trees may not indicate how close to the summer low flow elevation these species can grow now and in the future. It is likely that the vegetation is still adjusting to the relatively rapid downcutting that has occurred in recent decades, especially species that are slow growing and establish infrequently, like the two mentioned above.

Figure 20 shows understory shrub and sapling cover in the plots. In this and following figures, the size of each circle indicates the percent cover of a species in an individual plot. The biggest circles indicate 90-100 percent cover. Again, red willow tends to occur close to the stream in sandy soil. Sandbar willow lives up to its name and is found on gravelly sandbars very near the low water level. Snowberry is not a riparian obligate, but it is fairly common above bankfull elevations in the riparian corridor.

Vines were very important in the understory, as shown in **Figure 21**. The two most abundant vines are non-native pest plants, Himalaya berry and periwinkle. Both occur over a range of elevations and can form dense monocultures, occupying 100 percent of several plots. The native species that appears to be most displaced by these weeds is California wild grape, which is nonetheless common over a range of elevations and soils. A fourth vine that is also widely distributed within the riparian corridor is pipevine, a species with a very unusual flower and the host plant of the magnificent pipevine Swallowtail butterfly.

Percent cover of herbaceous species is shown in **Figure 22**. Both *Carex* (*C. obnupta* or *C. barbarae*, a definitive identification of all specimens was not made) and cutgrass were

common right at the water's edge, particularly in coarse substrata. The *Carex* species were also scattered higher above the river. Another *Carex*, *C. nudata*, occurs in the active stream channel, forming remarkable columnar clumps. The most common herbaceous plant away from the river's immediate edge was the introduced bedstraw, *Galium aparine*.

10. TREE CENSUS AND IMPACTS OF THE PROJECT ON THE EXISTING RIPARIAN CORRIDOR.

A census of large trees within the Napa River riparian corridor along the project reach was taken in order to document the potential large tree losses due to terrace excavation with the EMP. **Figure 23** shows a map of large trees on the channel banks where terrace excavation is proposed.

In order to preserve as many large trees as possible, the terrace excavations have been designed as overflow channels, similar to those observed on historical aerial photographs. On the north side of the Napa River, a 200-foot wide inlet will be excavated at the 2-year water surface elevation to convey overbank flow from the river to the new overflow channel. The overflow channel will be excavated on the land side of the drip lines of the preserved trees with benches set at an elevation capable of sustaining large trees such as oaks, cottonwoods, walnuts, bay laurel and Buckeye (**Figure 24**). The north side overflow channel will discharge into the Napa River about 1,800 feet downstream over a 200 foot wide excavated outlet.

The inlet to the southern terrace overflow channel will be excavated in a similar fashion with a 200-foot wide excavation at the upstream end. The length of bank preserved along the south side of the Napa River will be shorter, as large trees become sparse at the Vineyard Valley Mobile Home Park. Along the VVMHP, the south bank can be excavated to create a new geomorphic flood plain to support the wetter alder / willow / sedge communities.

Figure 25a shows the location of the trees that will be removed with the project and **Figure 25b** shows the trunk diameter distribution for certain tree species. **Appendix C** provides a summary detail of existing trees and trees to be removed under the Enhanced Minimum Plan.

11. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The proposed flood control project on the Napa River near St. Helena represents a significant opportunity to enhance the natural resource values by widening the riparian corridor and restoring natural geomorphic processes. Excavation of about 18 acres of high terrace will create significant opportunities to establish self-sustaining riparian vegetation communities in a corridor over 1,000 feet wide. Areas of large established bank trees will be preserved under the existing project. Areas of degraded or denuded banks will be enhanced through excavation of terrace surfaces to elevations capable of supporting a variety of riparian plant communities. This report provides the information

necessary to develop a detailed design for excavation of the new surfaces, planting and maintenance operations.

The proposed project addresses some key elements of concern for biological productivity in the Napa River (Stillwater Sciences, 2002), especially for salmonids (steelhead and chinook salmon). **Table 2** shows a list of potential salmonid life cycle limitations and the potential change associated with the proposed project. In general, a lack of Large Woody Debris (LWD) can be addressed as design features to be installed with the project. Other factors, such as shading, connectivity to flood plain surfaces and reduction in substrate mobility, could be improved with the project. The only potential negative impact appears to be the potential to strand migrating fish on the excavated terrace surface. However, this can be addressed in design by ensuring that the overbank areas drain positively towards the river channel on recession flows. On the other hand, the excavated terraces may be good high flow refuge areas, which are presently limited due to the incised channel.

Stillwater Sciences (2002) also investigated the historical changes in the river habitat that may have reduced salmonids' productivity. Stillwater found that the Napa River near St. Helena in 1940,

"...was a low gradient, gravel bedded stream exhibiting bar-pool morphology, with point bars, mid channel or island bars and multiple channels in unconfined reaches. These reaches were bordered by flood plains that appeared to be inundated annually with well established vegetation."

Also,

"Prior to anthropogenic disturbances in the basin, the Napa River would have had numerous side channels that provided backwater rearing habitat for salmonids. The main stem channel would have connected to it flood plain in most locations, with the flood plain inundated during several storms per year. In contrast, the 1998 aerial photographs depict a simplified river-flood plain system in which the channel has narrowed, incised and largely abandoned its former flood plain, resulting in a loss of backwater rearing habitat."

The proposed Enhanced Minimum Plan has the potential to reverse these changes by restoring flood plain through creation of backwater channels in the proposed terrace excavation and to increase the frequency and duration of overbank flow. The proposed project removes constraints to restoring habitat and a more functional channel flood plain system. Stillwater (2002) was unable to recommend any projects such as levee setbacks or gravel augmentation,

"...due to expected high social and economic costs of potential main stem restoration activities..."

In terms of impacts, the proposed project will have to be designed carefully to ensure that the desired vegetation communities are self-sustaining and exotic invasive plants are

Life Cycle Period	Factor	Potential Effect of St Helena Flood Control Project	Notes
Migration	Attraction Flows	0	
	Physical Barriers	0	
	Environmental Barriers	0	
	Migration Corridor Hazards	-	Overbank flow areas may become traps (BUT might be benefit for high flow refuge)
Spawning/Incubation	Spawning Gravel Quality	0 or +	Reduction in redd scour
	Spawning Gravel Quantity	0 or +	Reduced bedload transport force may cause gravel deposition
	Water Quality and Temperature	0 or +	Long term increase in bank vegetation may provide greater shading; introduction of LWD may deepen pools
	Substrate Mobility	0 or +	May be enhanced by reduced hydraulic force
	Redd dewatering	0	

Life Cycle Period	Factor	Potential Effect of St Helena Flood Control Project	Notes
Juvenile Rearing	Summer Rearing Habitat	+	Could restore backwater rearing habitat
	Overwintering habitat	+	Provide high flow refuge on terraces and in LWD
	Stranding by low flows	0	
	Displacement by high flows	+	High flow refuges on terraces and in LWD
	Predation	0	
	Food Availability	0 or +	Increased riparian corridor and overhanging vegetation
	Interaction with native species	0	
	Interaction with introduced species	0	
	Water Quality/Temperature	0 or +	Increased riparian cover could improve shade and buffer runoff from adjacent lands
Outmigration	Adequate Flows	0	
	Water Quality /Temperature	+	Wider riparian vegetation buffer might improve shading and filter local runoff
	Predation	0	
	Diversion Hazards	0 or -	Overbank flow above 2-year (could be high flow refuge)

controlled. This will be accomplished through a rigorous adaptive management plan to replace failed plants and to control undesirable plants.

The project and planting plan will have to be designed to hydraulically pass the design flood. Vegetation growth and sediment deposition in the channel or on new flood plain surfaces could potentially be a maintenance issue. The plant communities should be carefully selected in order to be compatible with the hydraulic roughness assumptions of the plan. The type of vegetation restored will depend upon the final grade, elevation above summer low water, and soil substrate. The concept presented in **Figure 24** shows overflow channels lined with dense overstory riparian vegetation at its ultimate development. If sediment deposition in the flood plain areas becomes excessive, excavation and vegetation removal could occur along the overflow channels to mimic flood disturbance; this technique has worked very well on the San Lorenzo River in the City of Santa Cruz, where annual vegetation removal in the late fall months is hardly detected in the following summer's growth and habitat quality.

A field reconnaissance investigation of soils and geology in the proposed excavation zones found that the areas are underlain by deep, loamy soils (**Figure 26**). Some reaches immediately downstream of the project reach have substantial bedrock control lining the low flow channel and at shallow depths below the channel banks. The project reach exhibits deep loamy soils that, when excavated, should be appropriate substrate for riparian vegetation after construction.

In summary, the proposed enhanced minimum plan will have significant environmental benefits that outweigh any potential negative impact with respect to geomorphic channel stability and riparian ecology. An analysis of bedload transport found little difference between existing conditions and those under the proposed plan. Overbank sedimentation rates could improve over existing conditions as current overbank flow begins at a ten-year flood of 11,000 cfs, while the plan calls for overbank flow onto flood plain surfaces perhaps on an annual basis. A precise calculation of the differences is beyond the scope of this work, however other information suggests that overbank sedimentation is not significant during large floods. Based upon a review of recently completed limiting factors study for salmonids productivity by Stillwater Sciences (2002) on the Napa River, the proposed project could address several key areas of habitat and water quality concern.

The following are recommendations to be carried out during the detailed design, construction and adaptive management-monitoring program.

- 1) In the grading plan for the terraces utilize overflow channels to preserve existing large trees and to create a set of benches set at specific elevations to support desired vegetation communities. The overflow channels should mimic historical examples, which show a frequently scoured channel bed and banks lined in dense riparian vegetation.
- 2) Develop a vegetation plan to address the planting plan and methods for achieving the desired plant community coverage and for controlling undesirable invasive and exotic vegetation. The plan would include an initial revegetation plan and an

adaptive management plan for installation and establishment. The plan should use the information contained within this report to guide preparation of a design.

- 3) Establish large overstory canopy trees (i.e. cottonwood or oak) with clear understory of grasses and shrubs in the newly created overbank areas that are to retain low roughness values (Mannings $n = 0.050$ maximum). Areas dedicated to high hydraulic resistance with dense vegetation should be situated along the banks of the Napa River low flow and bankfull channels.
- 4) Salvage as many native plants from the existing river banks as possible during construction and replant them as quickly as possible at appropriate elevations as described in this report. Between the time of salvage and replanting, store plants in a shaded area with roots covered by moist soil or burlap and water them at the time of replanting and as needed until established or dead. Although there will be mortality, this transplanting operation should result in the successful relocation of many small oaks and other trees, shrubs, and vines.
- 5) Remove noxious weeds, giant reed (*Arundo donax*), periwinkle (*Vinca major*), and Himalaya berry (*Rubus discolor*) to the maximum extent possible during terrace construction. Completely excavate giant reed infestations out of streambanks and all plant parts destroyed. For the other two species, root systems and runners will be too intermingled with other plants to eliminate entirely in many cases, but solid patches can be excavated.
- 6) Survey terraces every three months for at least 1-2 years and then every spring and summer after that, and remove any newly establishing weeds. Newly establishing weeds should be easy to pull. In contrast, established plants may be virtually impossible to eliminate. Thus, prevention is the key to minimizing the growth of non-native pest plants that exclude the native plants upon which wildlife depend. Over time, with the establishment of native vegetation on the terraces, these areas will be more resistant to invasion by weeds and weed control efforts will be easier.
- 7) Make provisions for monitoring the topography and sediment deposition on overbank areas to determine when maintenance might be needed. Maintenance would take the form of vegetation management (pruning, mowing and planting) in order to eventually achieve a late successional riparian forest on the main stem Napa River and created flood overflow channels and sediment removal from overflow channel bed areas.

12. ENVIRONMENTAL IMPACTS AND BENEFITS COMPARISON

A comparison of environmental impacts between the minimum plan and the enhanced minimum plan (CDM 2002) was made for the purposes of evaluating impacts and benefits.

The preceding analysis addressed the enhanced minimum plan, which represents a more expansive project. The minimum plan has the same extent of terrace excavation on the

north side of the Napa River, but a significantly reduced area of excavation on the south side. Fewer mobile homes would be moved under the minimum plan and the acreage for riparian restoration would be reduced by about 40 percent, to approximately 12 acres total. The minimum plan would include a more extensive flood plain and levee system than the enhanced minimum plan. The minimum plan does not include the extension of Adams Street nor a new bridge, as proposed under the EMP.

The following is a comparison of the key impact areas for geomorphology and vegetation as discussed above.

Channel Stability: The minimum plan should have similar hydraulic characteristics as the enhanced minimum plan and therefore it is anticipated that the bedload transport would be similarly affected. Since the proposed projects involve a reduction in hydraulic force and shear caused by reductions in flow depth, there could be some benefits to chinook and steelhead spawning redd survival.

Overbank Sedimentation: The difference between the EMP and the MP is less acreage of overbank flow area, such that the minimum plan would have less area for sediment deposition. The MP would have significant area of low flood plain as compared to existing conditions, so the frequency and duration of flooding would be similar to the EMP.

Vegetation Impacts: The impacts to the existing riparian corridor trees are higher with the MP than the EMP because the south bank riparian vegetation is not preserved. The potential for riparian vegetation restoration with the minimum plan is less (12 acres) than the EMP (18 acres). Both the MP and EMP will have significant environmental benefits to riparian habitat in the project reach, by increasing the frequency and duration of overbank flow and by reducing the relief between the terrace surfaces and summer low water.

13. REFERENCES CITED

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- Hickman (ed.) 1993: The Jepson Manual: Higher Plants of California. University of California Press, Berkeley, CA.
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Napa River Basin, California

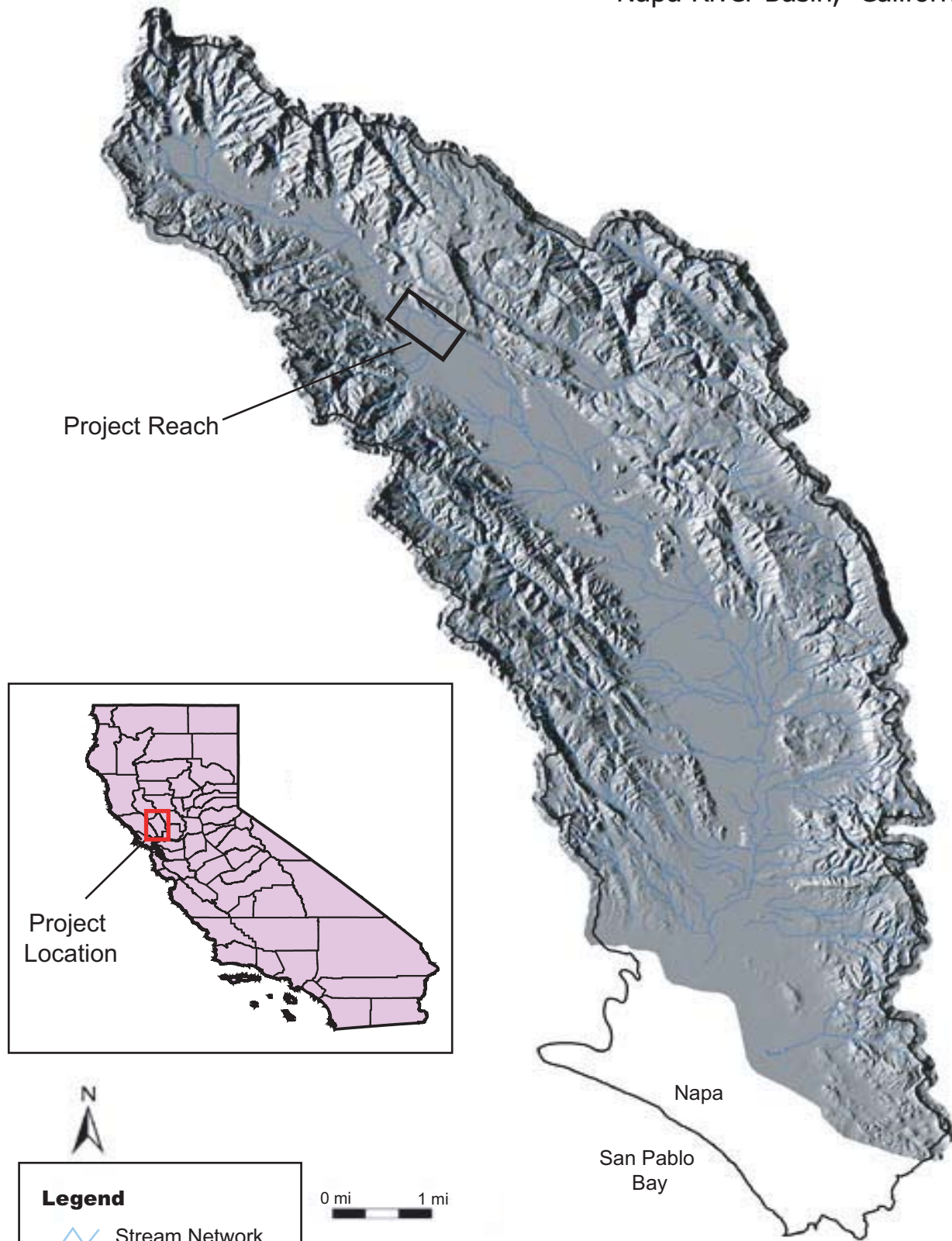
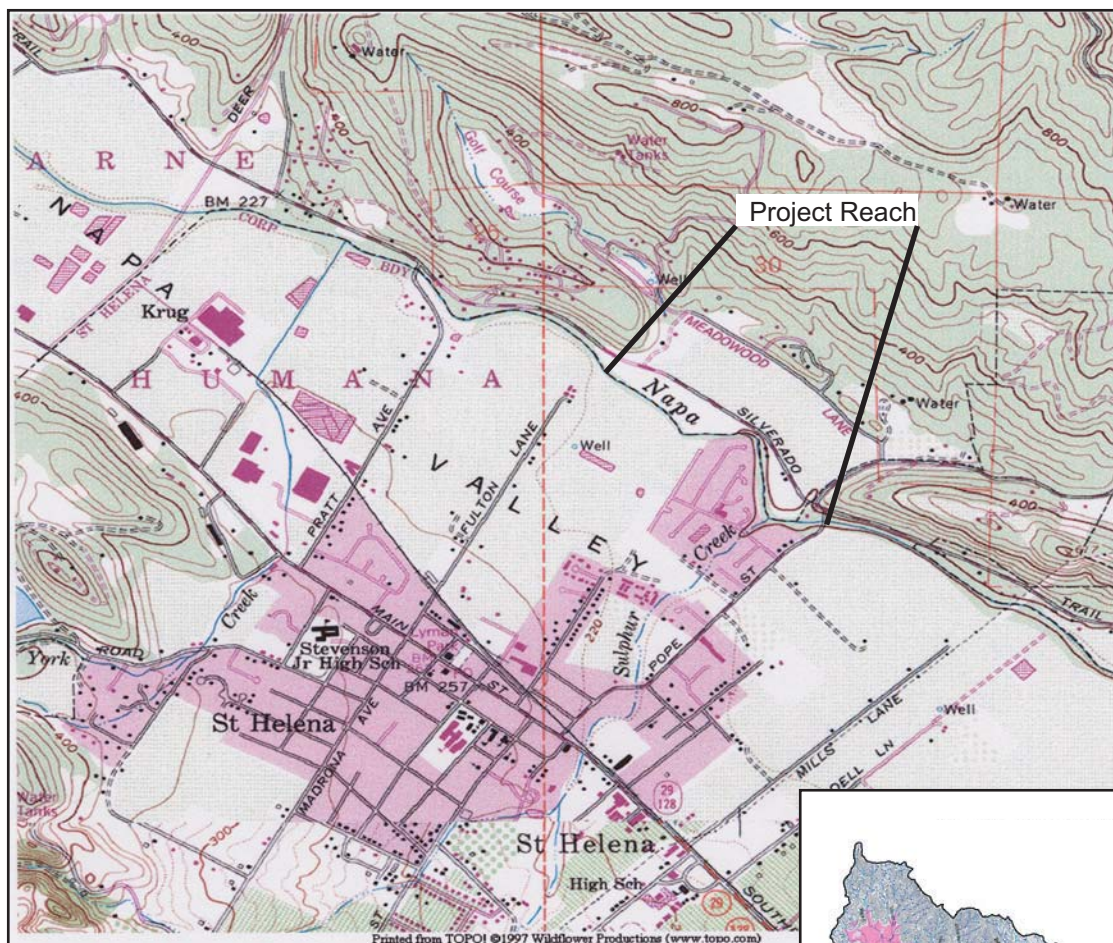
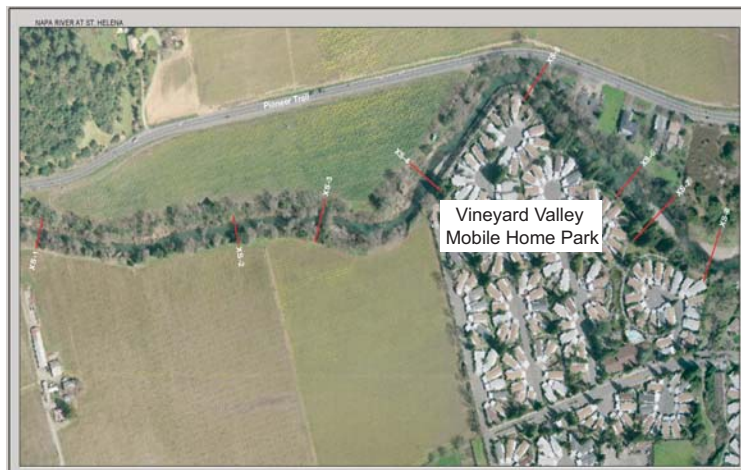
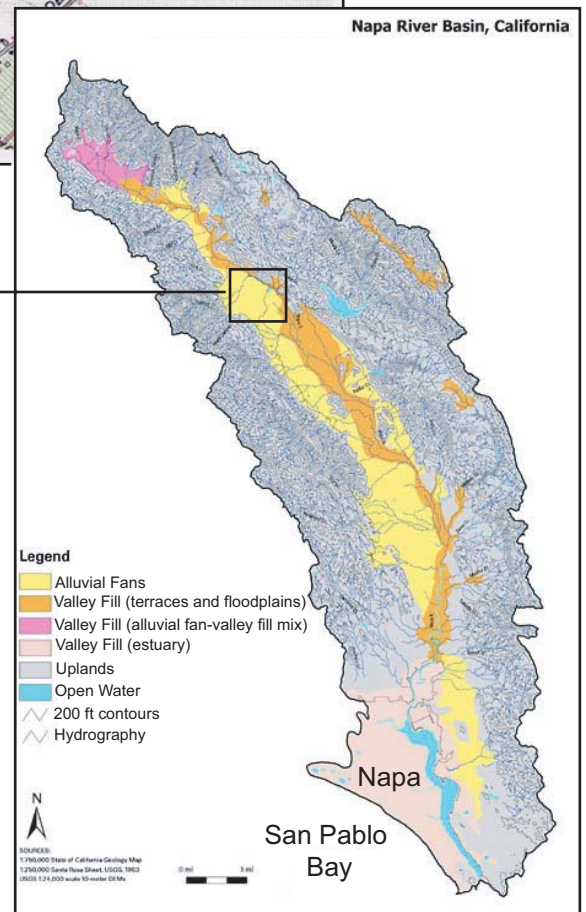


Figure 1: Napa River Basin watershed map.

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Vicinity Map



Project Reach







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Figure 2: Vicinity map showing the project reach of the Napa River near St. Helena.



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Figure 3: Napa River near St. Helena flood control project map

- | | | |
|---|---|--|
|  Construct Terrace Channel |  Extend Adams Street |  Excavate and Replant Terrace |
|  Old Flood Channel |  New Bridge (Adams Street) |  Maintain Willow Shrub Scrub and Emergent |



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Figure 4: Napa River at downstream face of Zinfandel Bridge several miles downstream of project site. The bridge has been repaired numerous times since its construction in 1930 due to 6-8 feet of channel bed incision or degradation.



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Figure 5: 1850's local plot map showing the Napa River with essentially the same location as today.
 Source: City of St. Helena.



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Figure 6: Napa River near upstream end of project boundary. Note clear channel bed with overstory shading provided by canopy. All oak trees in this area to be preserved with project.



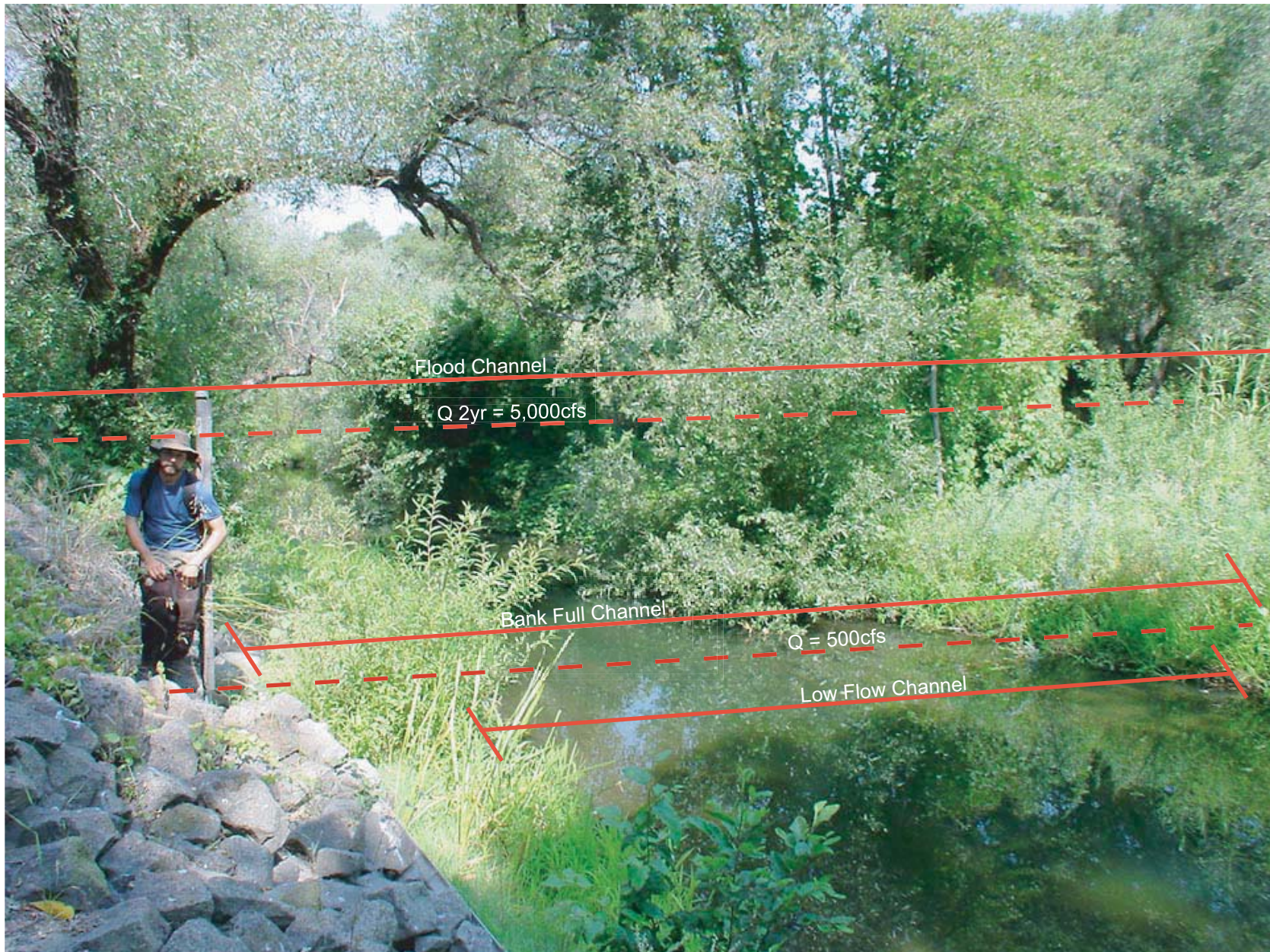
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Figure 7: Napa River looking upstream near Vineyard Valley Mobile Home Park. This reach is open to sunlight which promotes early successional growth of willow-sedges and cattails



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Figure 8: Napa River upstream of St. Helena showing wide riparian corridor with multiple flood channels in July 1940.
(scale is approximately 1" = 750')



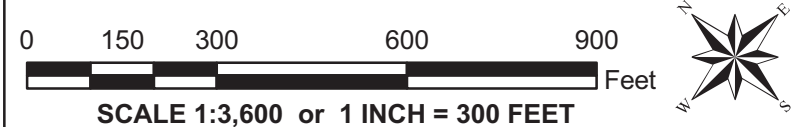
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Figure 9: Napa River near St. Helena USGS gaging station showing various stage channels and corresponding discharge values.



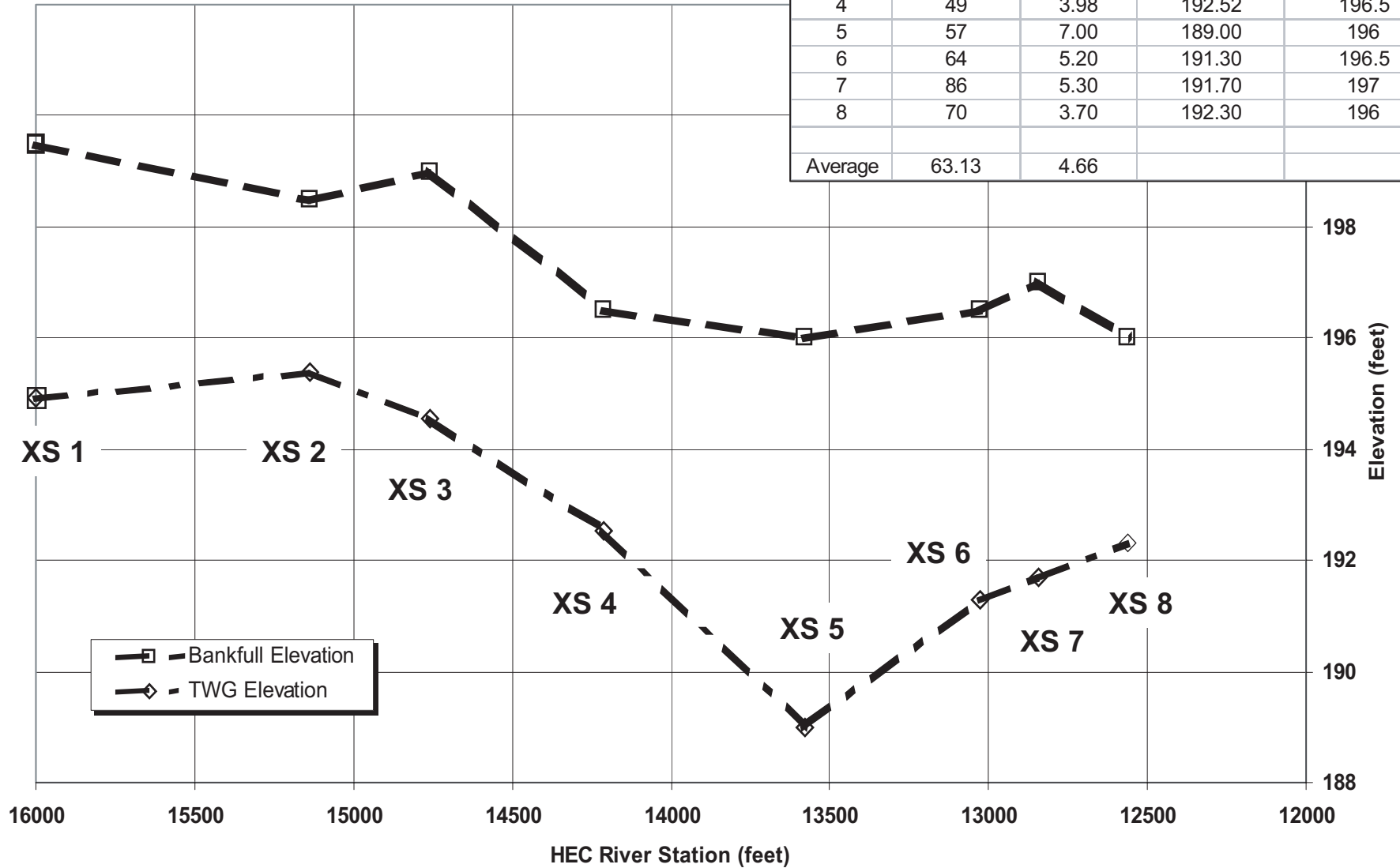
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Figure 10: SH&G measured cross sections (XS) 1 - 8
 in project reach.



Napa River at St. Helena Bankfull Elevations at Cross-sections

XS	Width (ft)	Depth (ft)	TW Elev.	Bankfull Elev.
1	51	4.57	194.93	199.5
2	62	3.11	195.39	198.5
3	66	4.45	194.55	199
4	49	3.98	192.52	196.5
5	57	7.00	189.00	196
6	64	5.20	191.30	196.5
7	86	5.30	191.70	197
8	70	3.70	192.30	196
Average	63.13	4.66		





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Figure 12: Napa River near St. Helena near SH&G cross section #2. Undercut group of alders are situated at bankfull flow with a depth of about 4.5 feet and width of 55 feet. Note scour below bankfull flow.

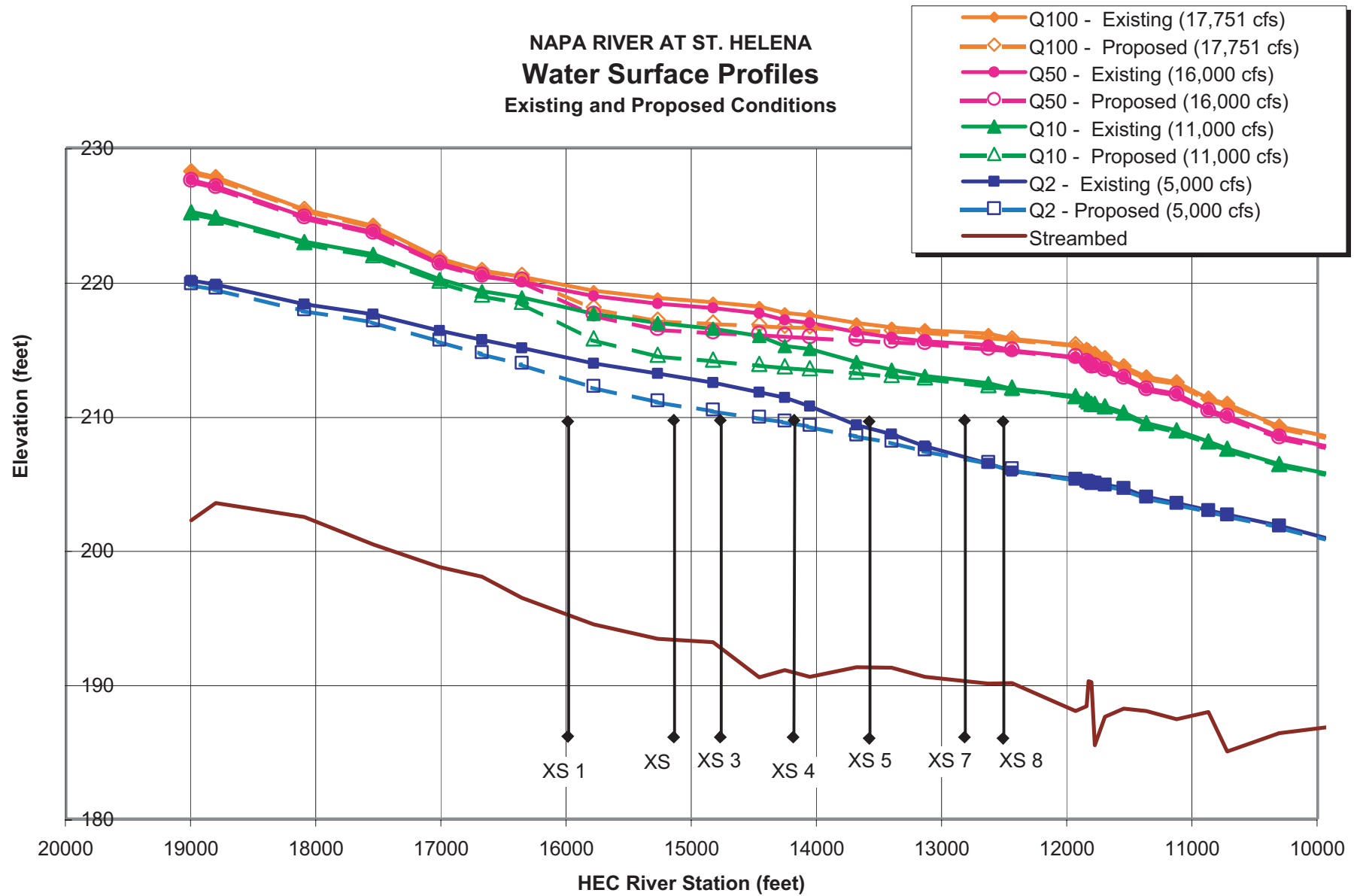
PEBBLE COUNT RESULTS

Station	D84 (mm)	D50 (mm)	D16 (mm)	% Finer							
				(0-2mm)	(2-4mm)	(4-8mm)	(8-16mm)	(16-32mm)	(32-64mm)	(64-128mm)	(>128mm)
XS-1	43	30	21	0	0	1	9	51	36	3	0
XS-2	62	40	21	0	0	1	10	20	54	15	0
XS-3	55	15	8	2	0	16	42	30	9	0	1
XS-4	66	47	26	1	0	0	1	26	53	19	0
XS-5	67	40	40	2	0	1	6	32	40	19	0
XS-7	87	61	44	0	0	0	0	7	37	36	0
XS-8	68	39	21	1	0	1	6	30	41	20	0



Figure 13a: Pebble count data for each SH&G cross section.

NAPA RIVER AT ST. HELENA
Water Surface Profiles
 Existing and Proposed Conditions



NAPA RIVER AT ST. HELENA
Shear Stress for 2-year Flood (5,000 cfs)

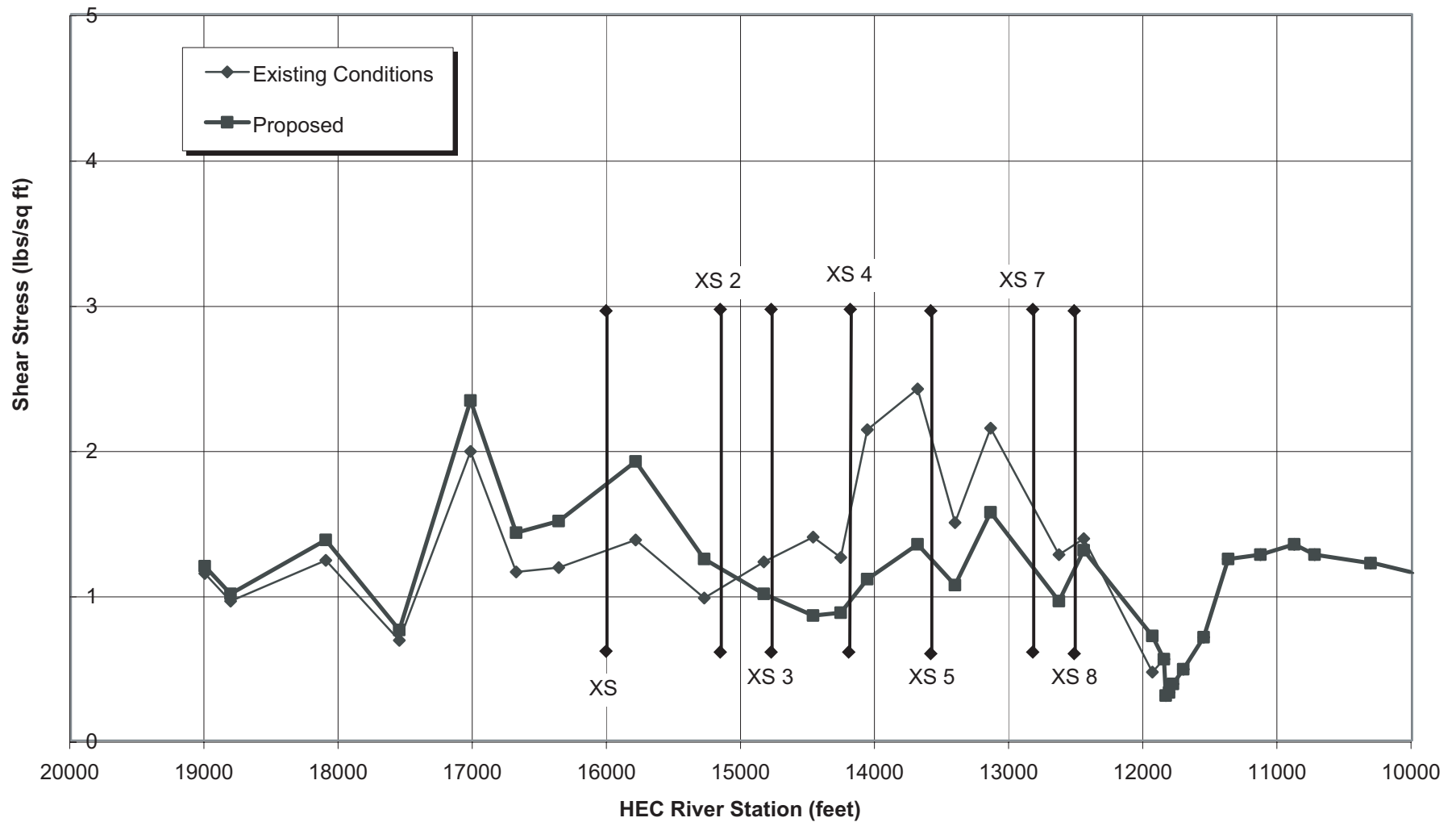


Figure 14a: Shear stress profiles with and without Enhanced Minimum Plan for a 2-year flood. XS refers to location of SH&G cross sections.

NAPA RIVER AT ST. HELENA
Shear Stress for 10-year Flood (11,000 cfs)

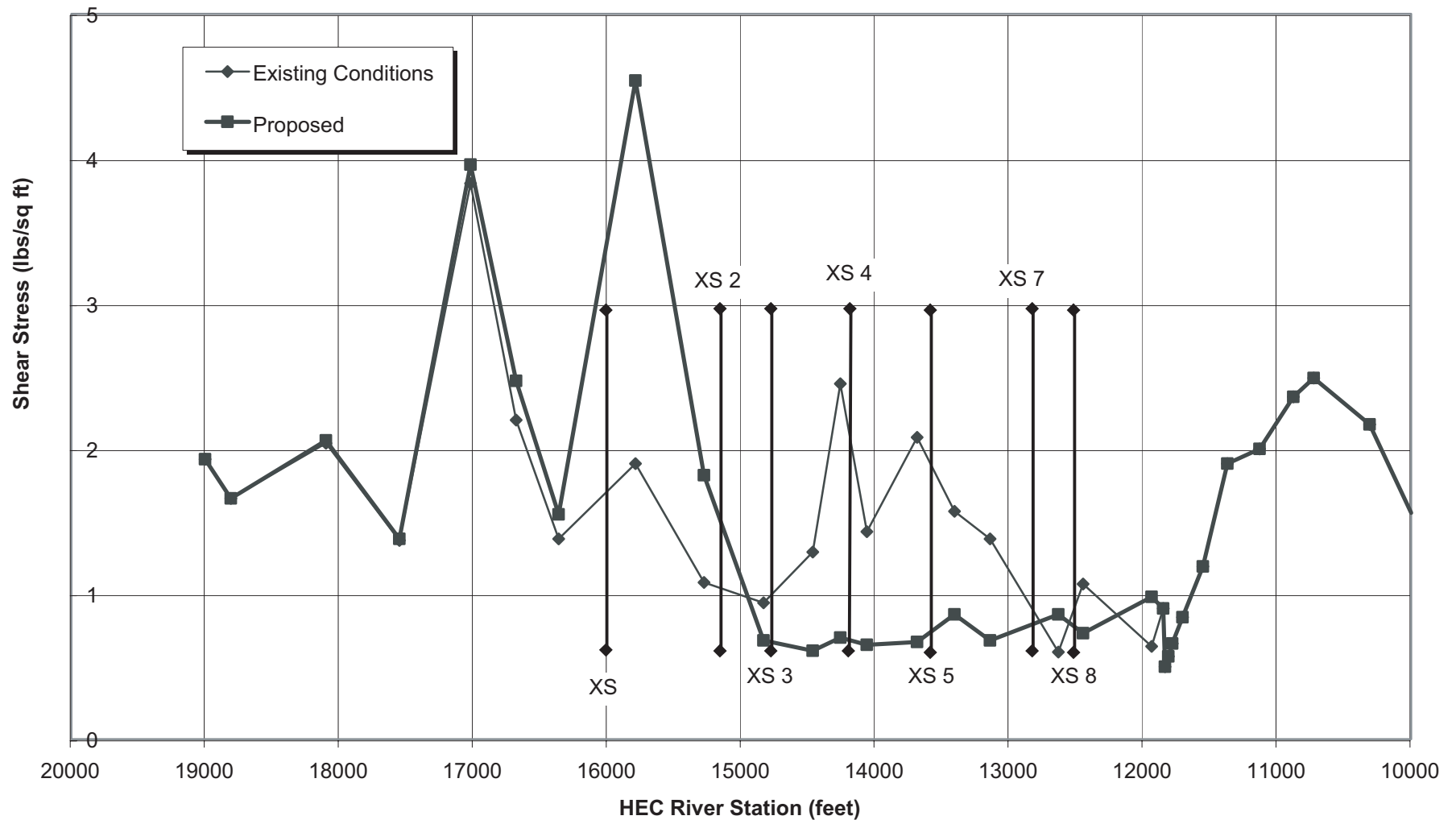
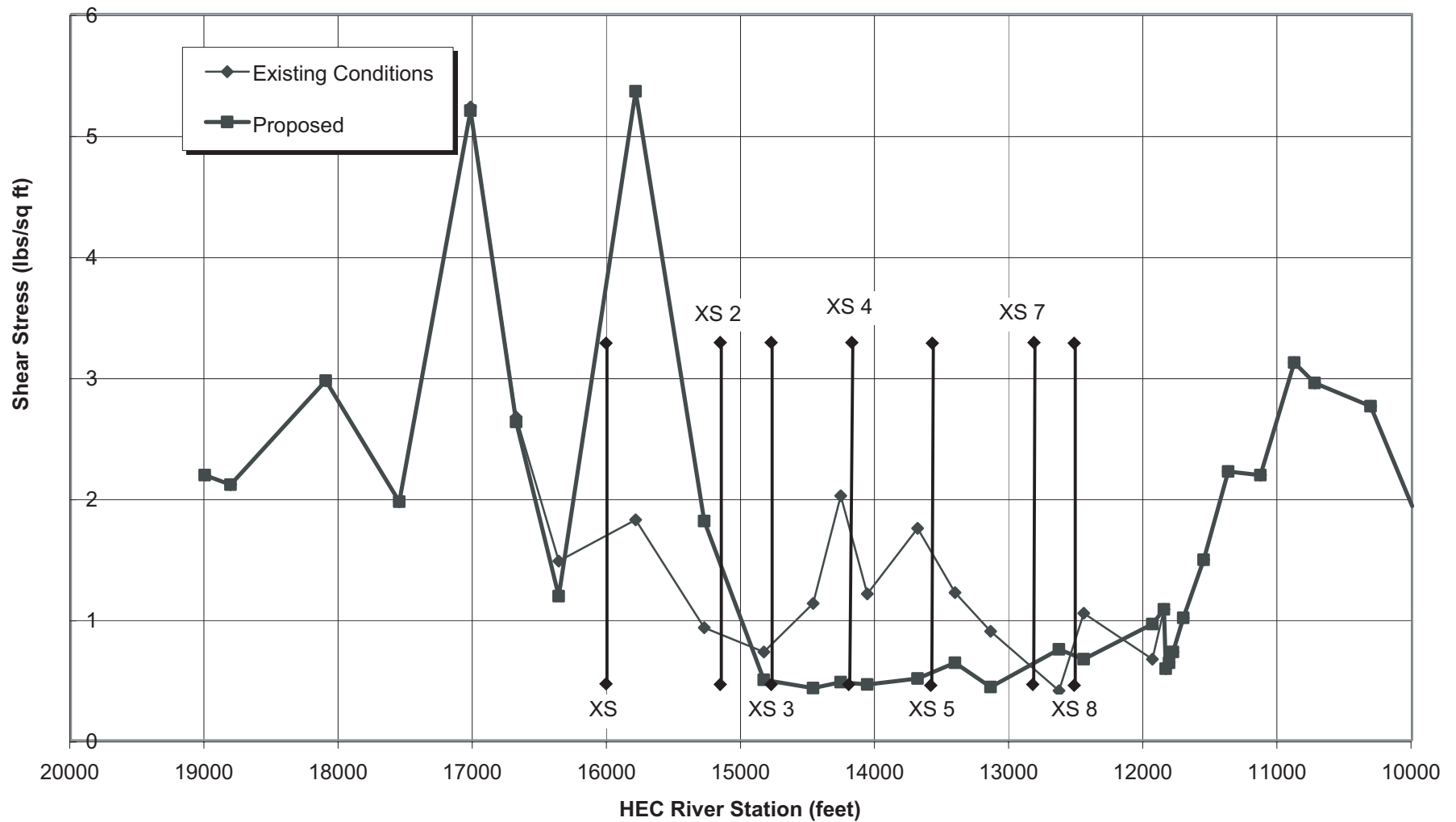


Figure 14b: Shear stress profiles with and without Enhanced Minimum Plan for a 10-year flood. XS refers to location of SH&G cross sections.

NAPA RIVER AT ST. HELENA
Shear Stress for 50-year Flood (16,000 cfs)



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Figure 14c: Shear stress profiles with and without Enhanced Minimum Plan for a 50-year flood. XS refers to location of SH&G cross sections.

NAPA RIVER AT ST. HELENA
Shear Stress for 100-year Flood (17,751 cfs)

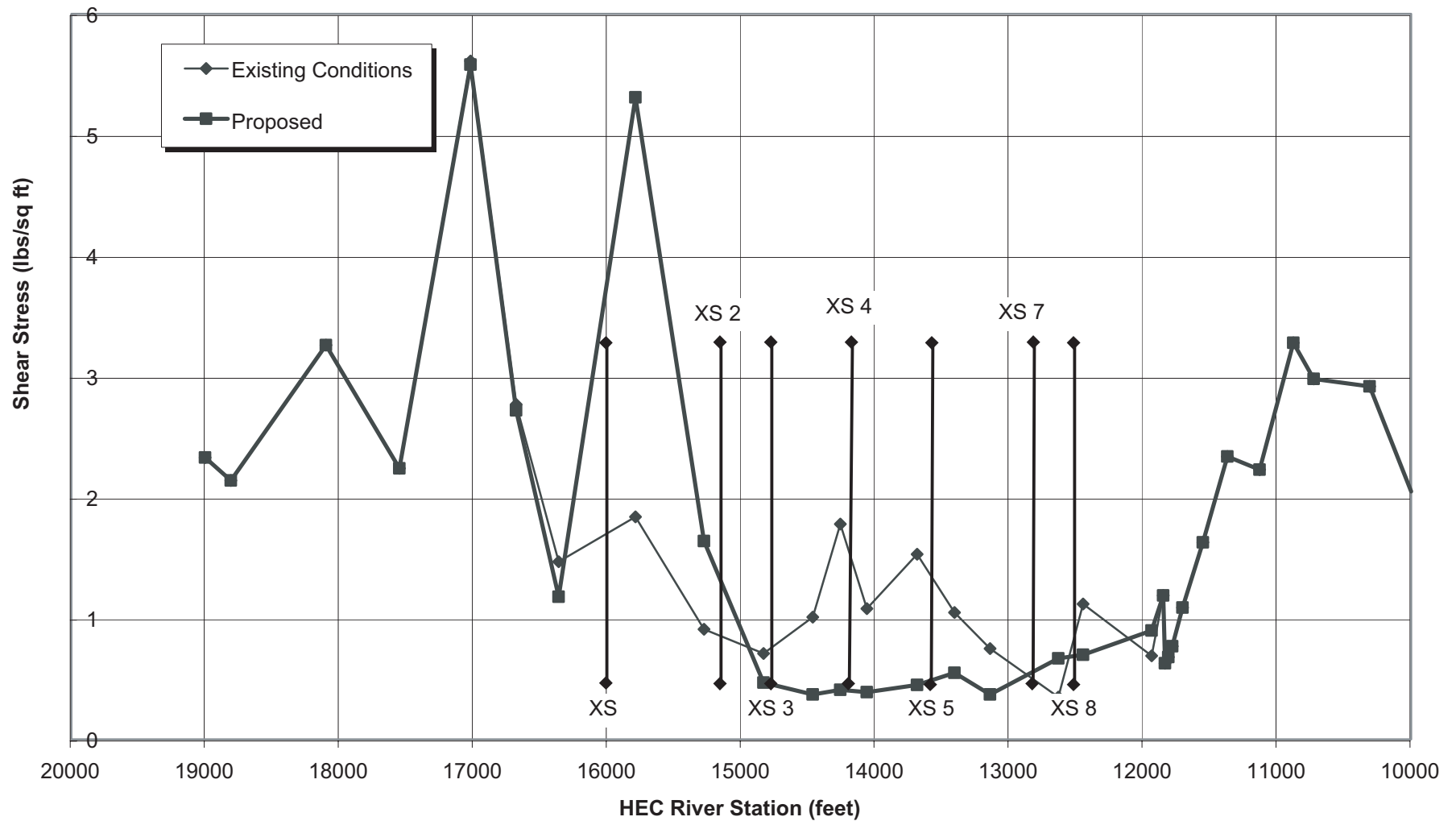


Figure 14d: Shear stress profiles with and without Enhanced Minimum Plan for a 100-year flood. XS refers to location of SH&G cross sections.

**NAPA RIVER AT ST. HELENA
SHG Cross-section 1 (HEC Station 16000)**

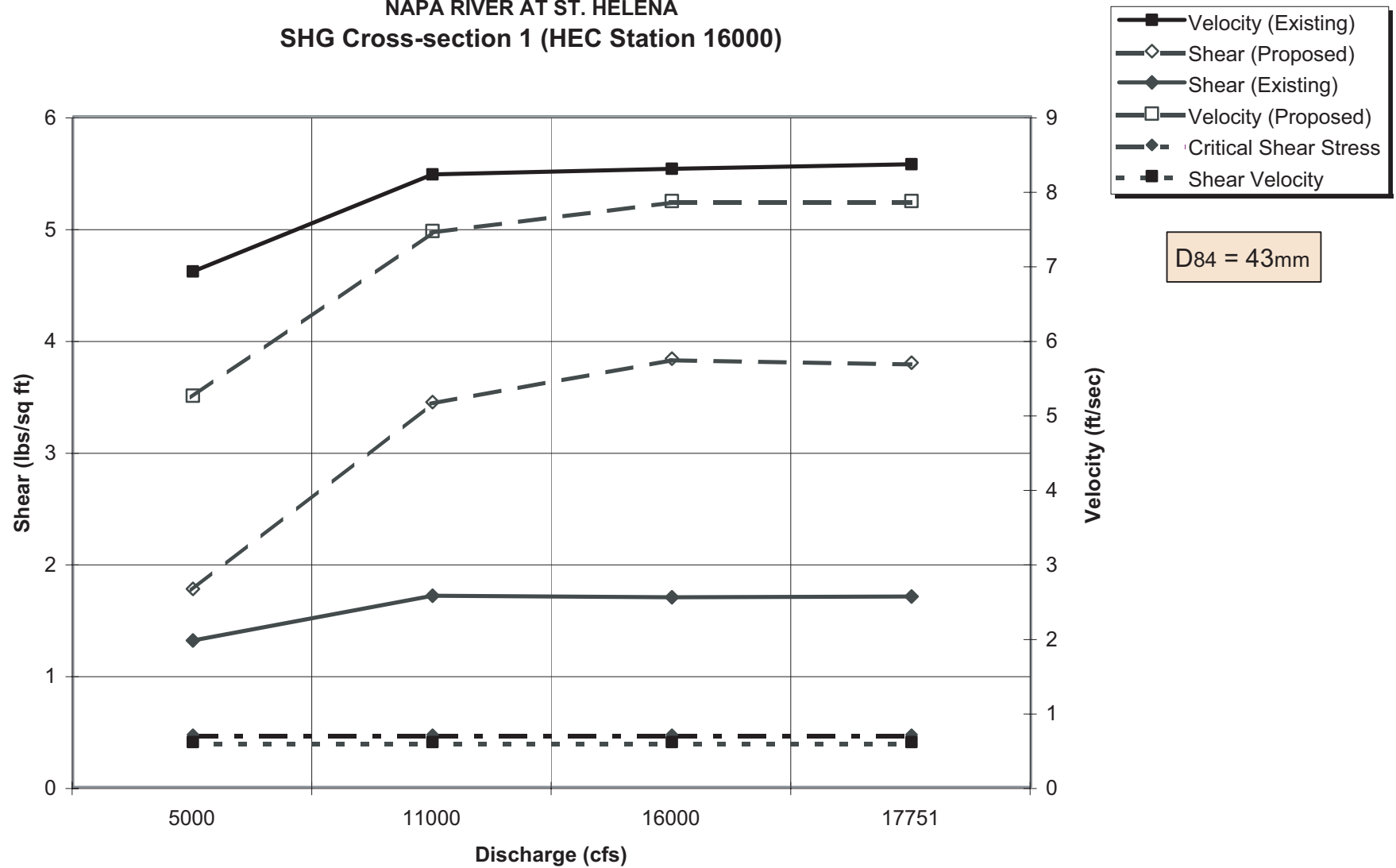


Figure 15a: Plot of shear stress versus flow for SH&G cross section 1.

**NAPA RIVER AT ST. HELENA
SHG Cross-section 2 (HEC Station 15136)**

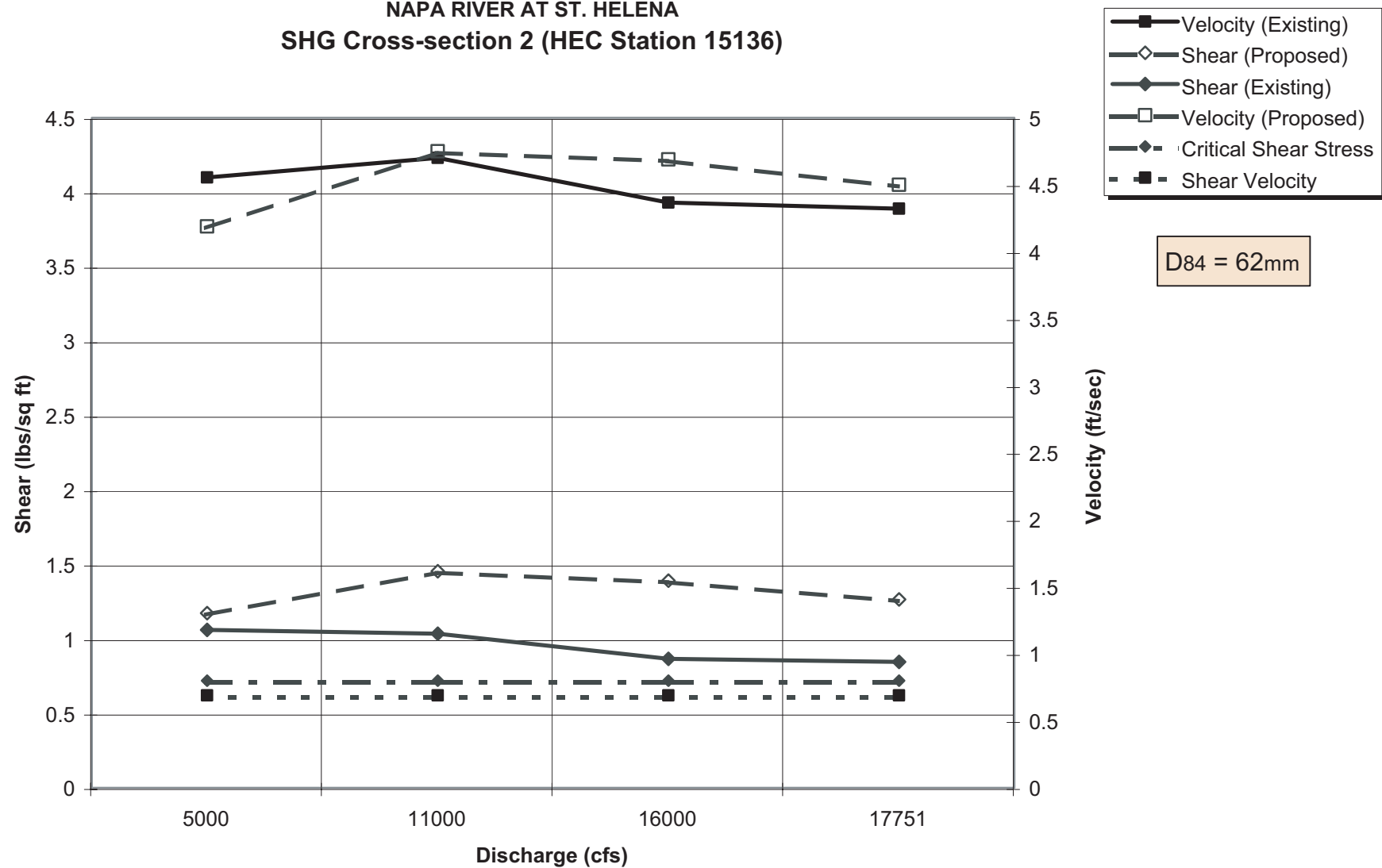


Figure 15b: Plot of shear stress versus flow for SH&G cross section 2.

**NAPA RIVER AT ST. HELENA
SHG Cross-section 3 (HEC Station 14757)**

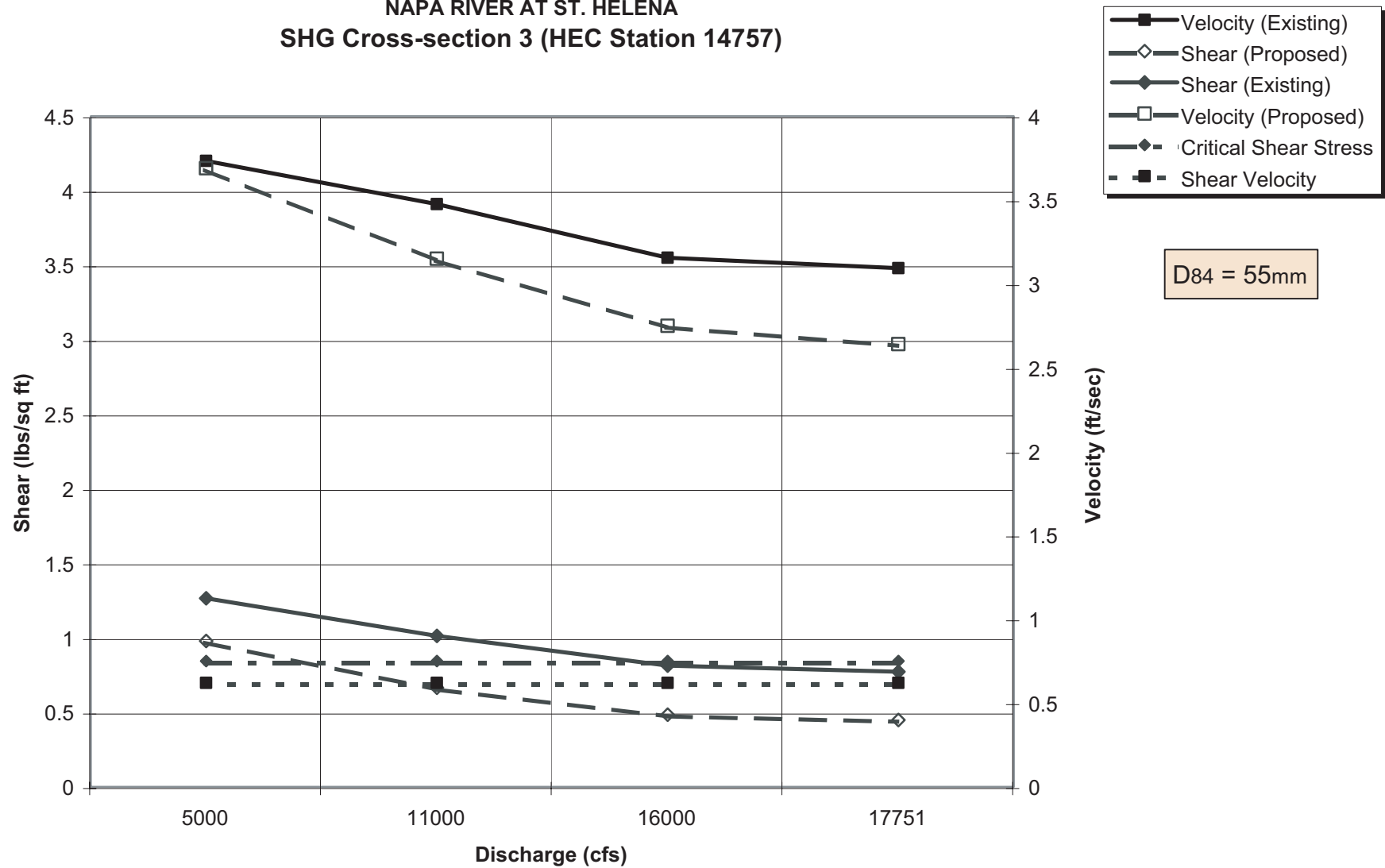


Figure 15c: Plot of shear stress versus flow for SH&G cross section 3.

**NAPA RIVER AT ST. HELENA
SHG Cross-section 4 (HEC Station 14214)**

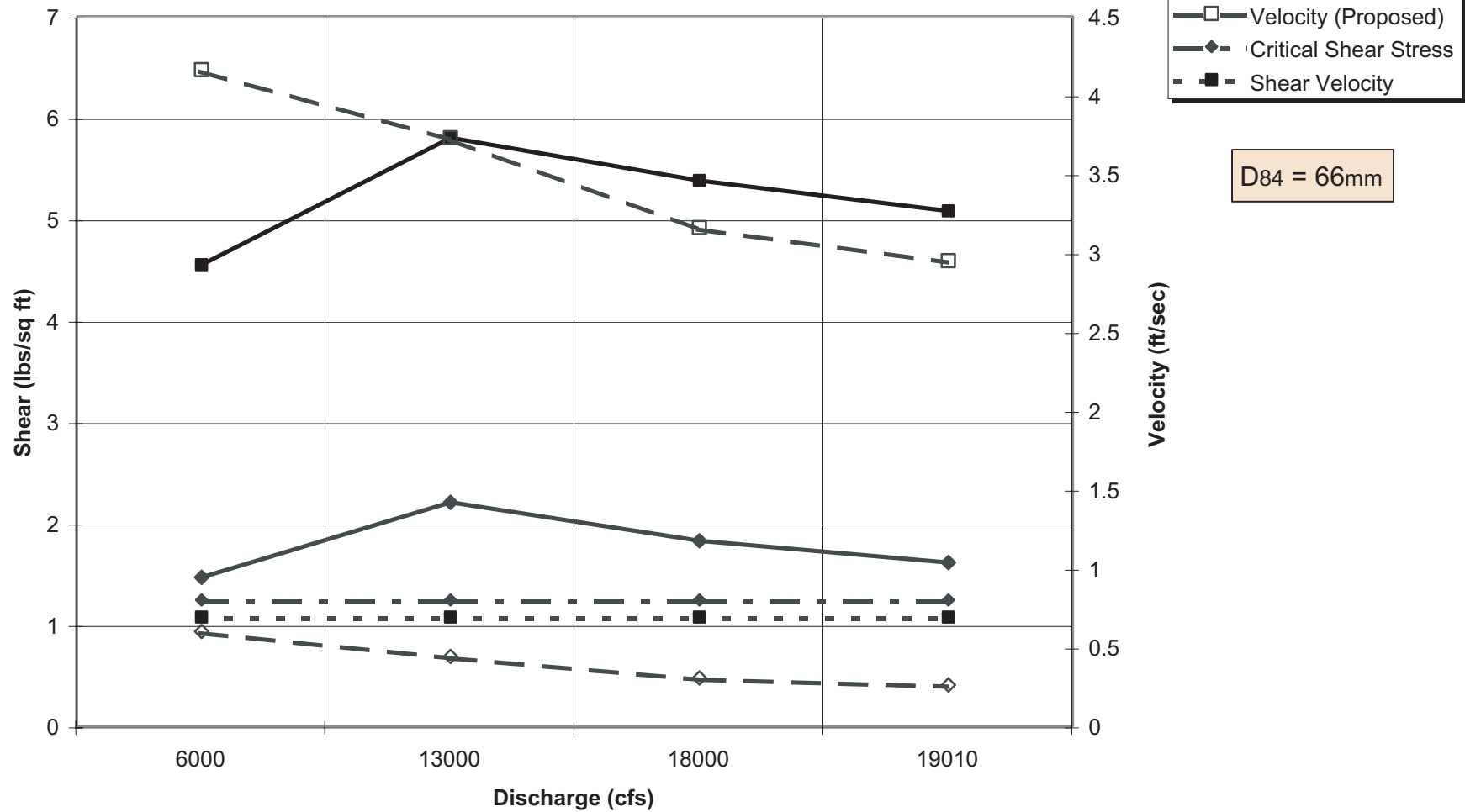


Figure 15d: Plot of shear stress versus flow for SH&G cross section 4.

**NAPA RIVER AT ST. HELENA
SHG Cross-section 5 (HEC Station 13578)**

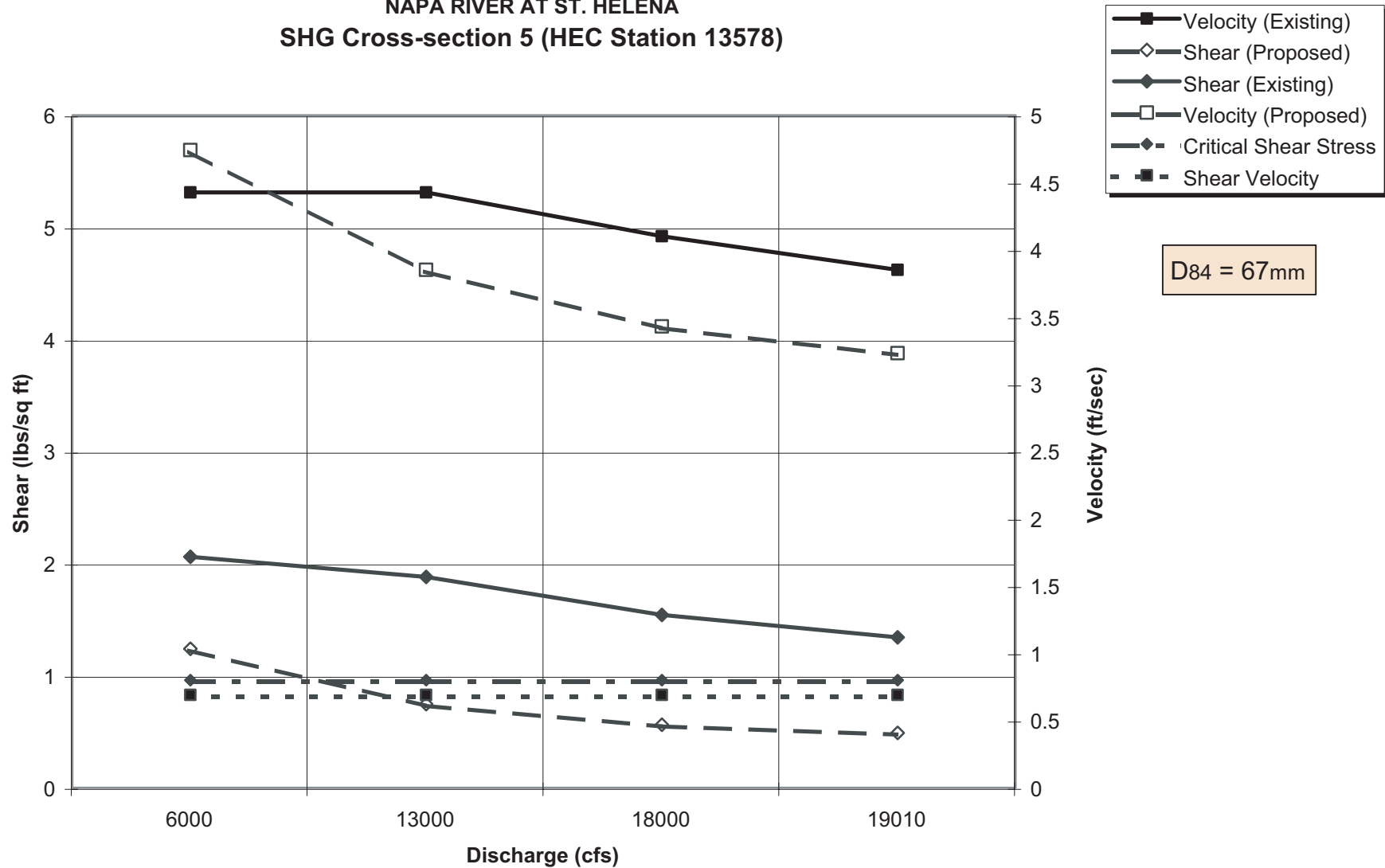


Figure 15e: Plot of shear stress versus flow for SH&G cross section 5.

**NAPA RIVER AT ST. HELENA
SHG Cross-section 7 (HEC Station 12845)**

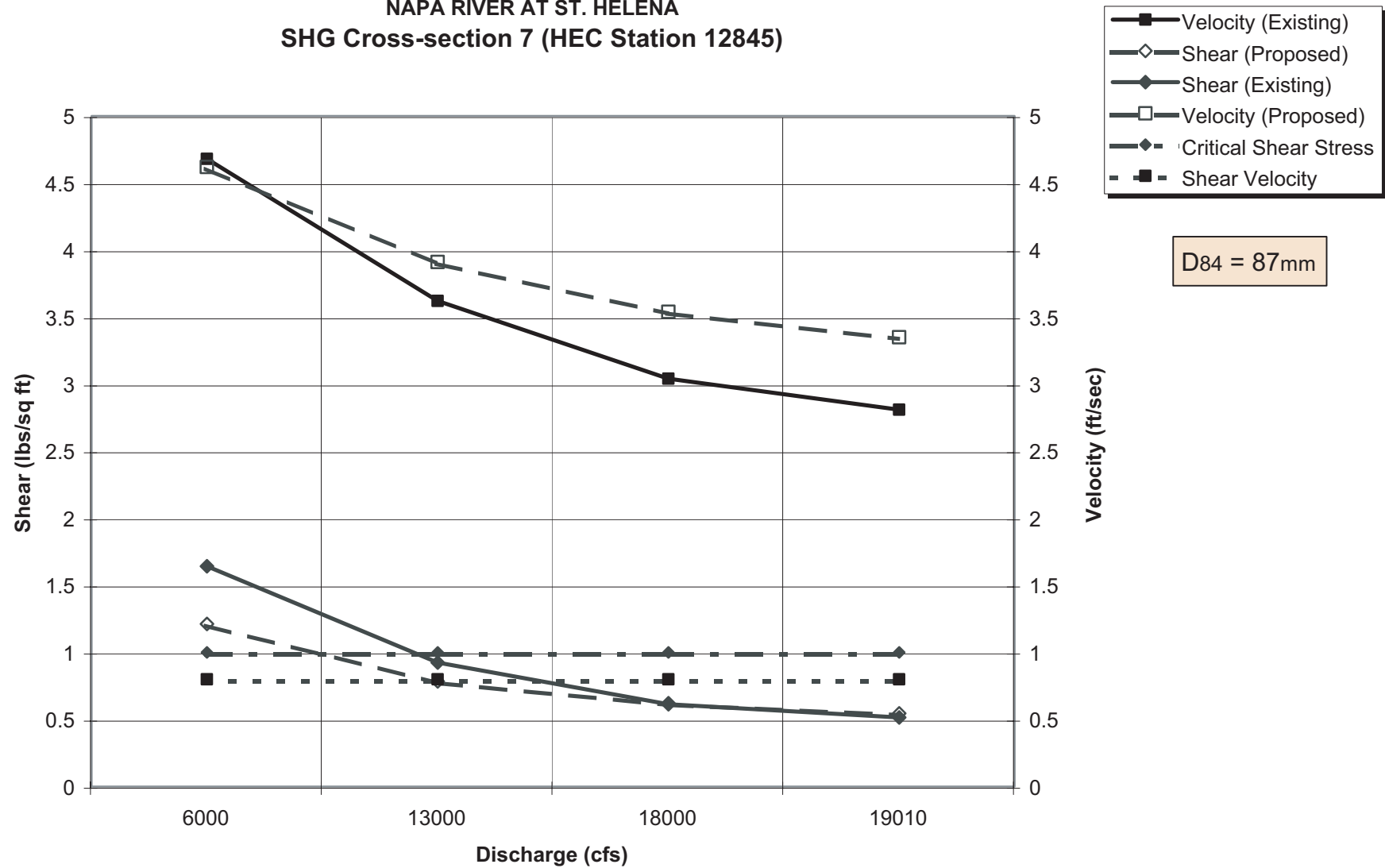


Figure 15f: Plot of shear stress versus flow for SH&G cross section 7.

**NAPA RIVER AT ST. HELENA
SHG Cross-section 8 (HEC Station 12562)**

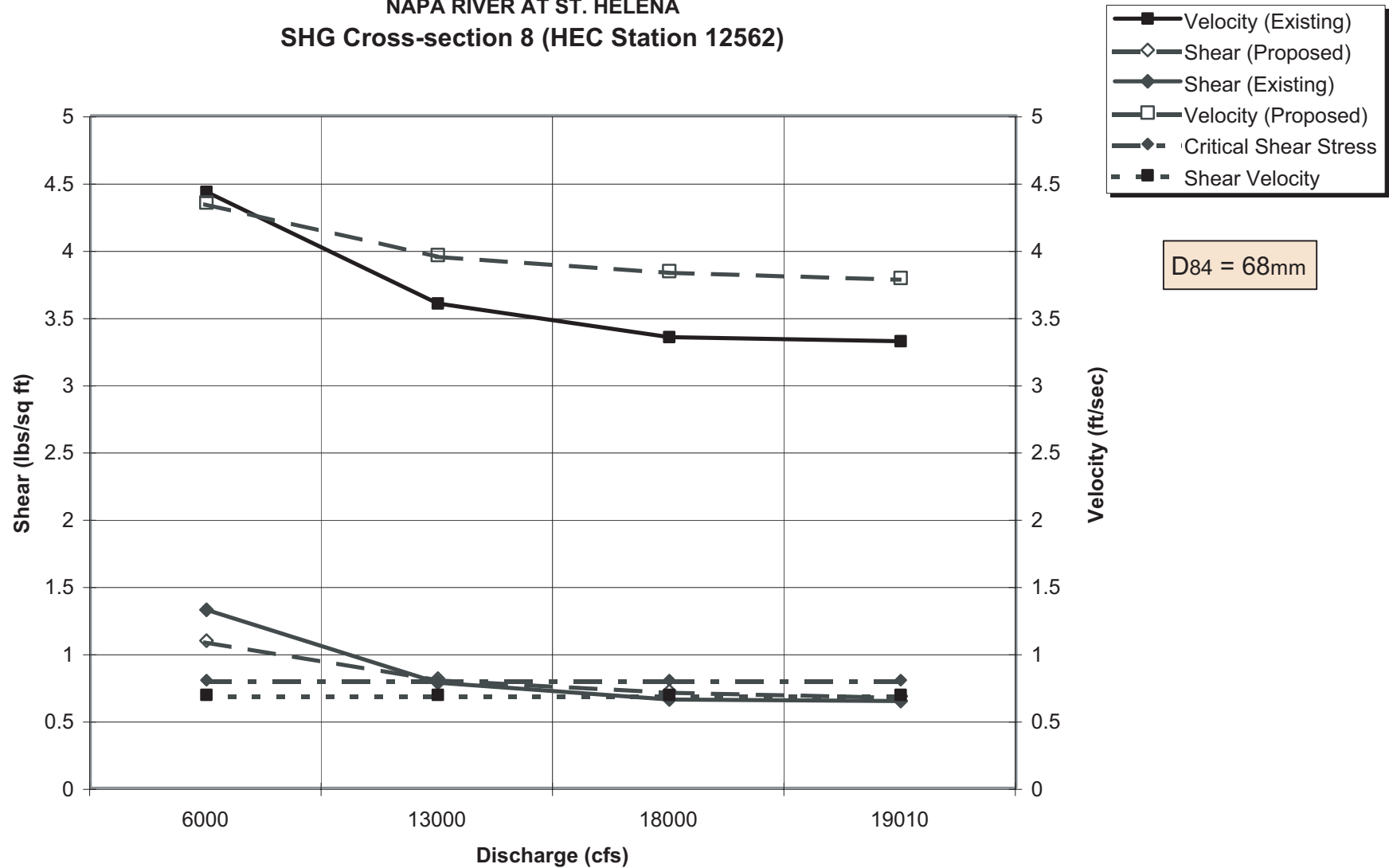


Figure 15g: Plot of shear stress versus flow for SH&G cross section 8.

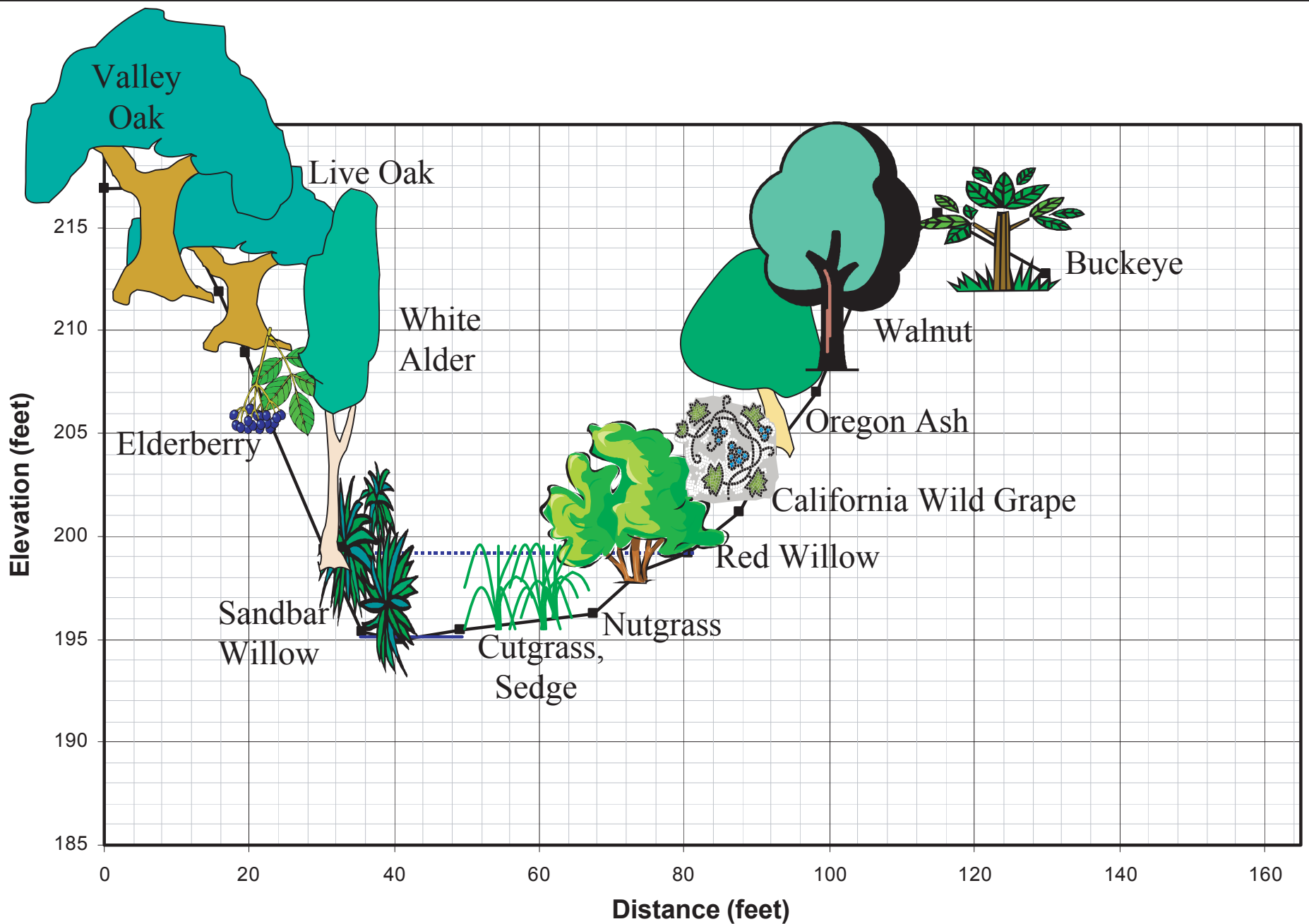


Figure 16: Generalized vegetation relationships along actual SH&G cross section 1.

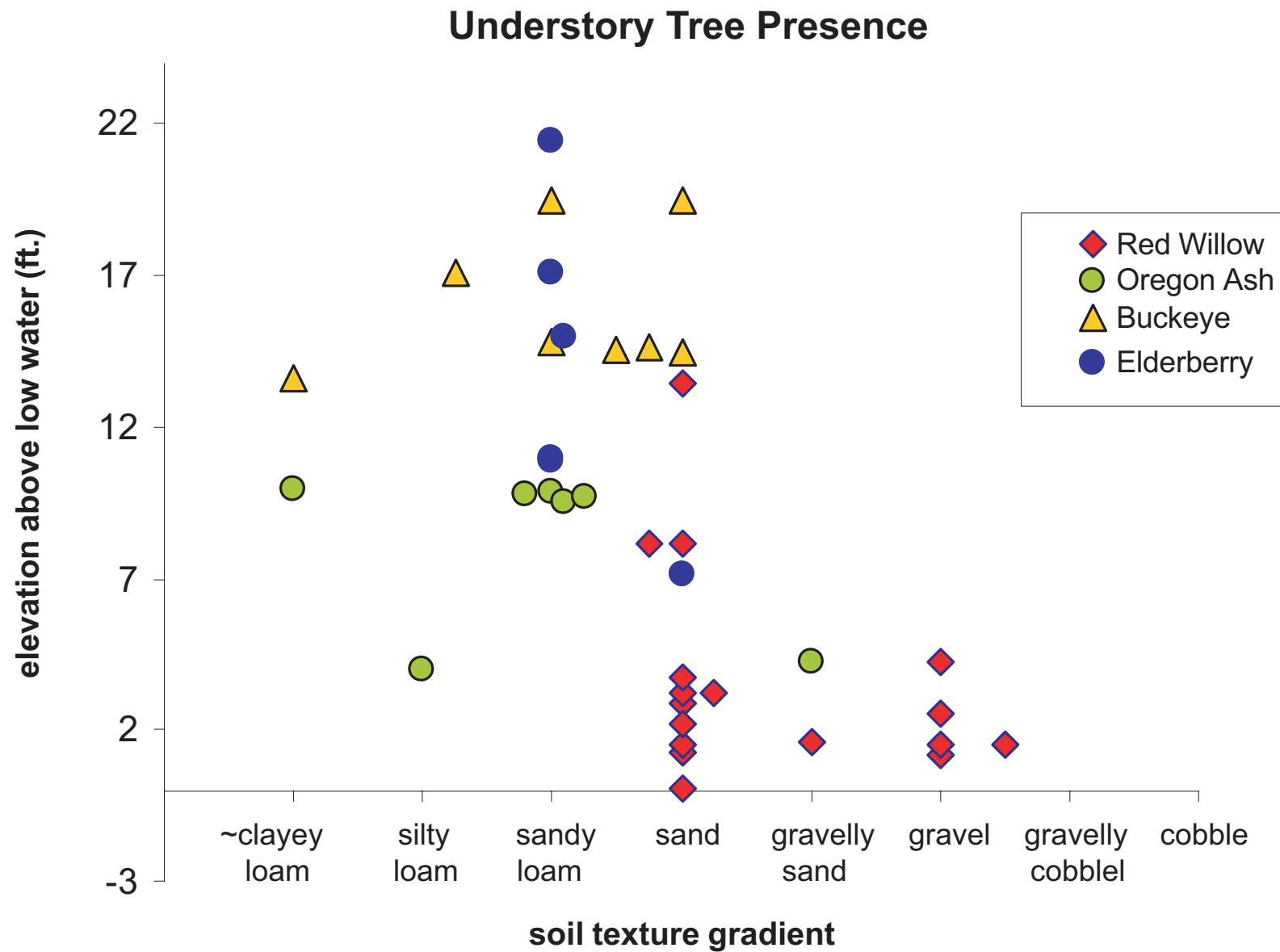


Figure 18: Relation of understory tree occurrence to elevation above summer low flow and soil texture.

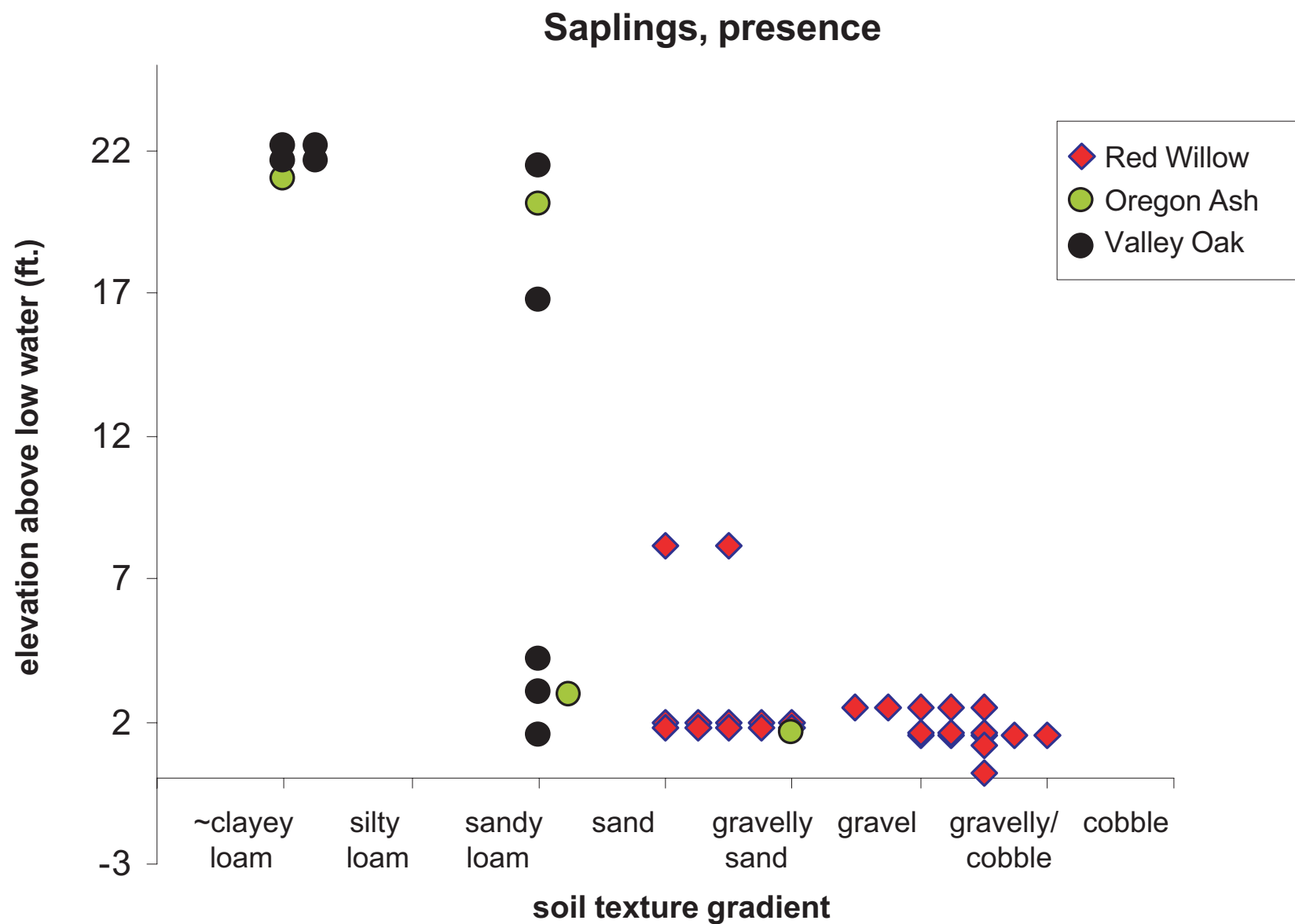
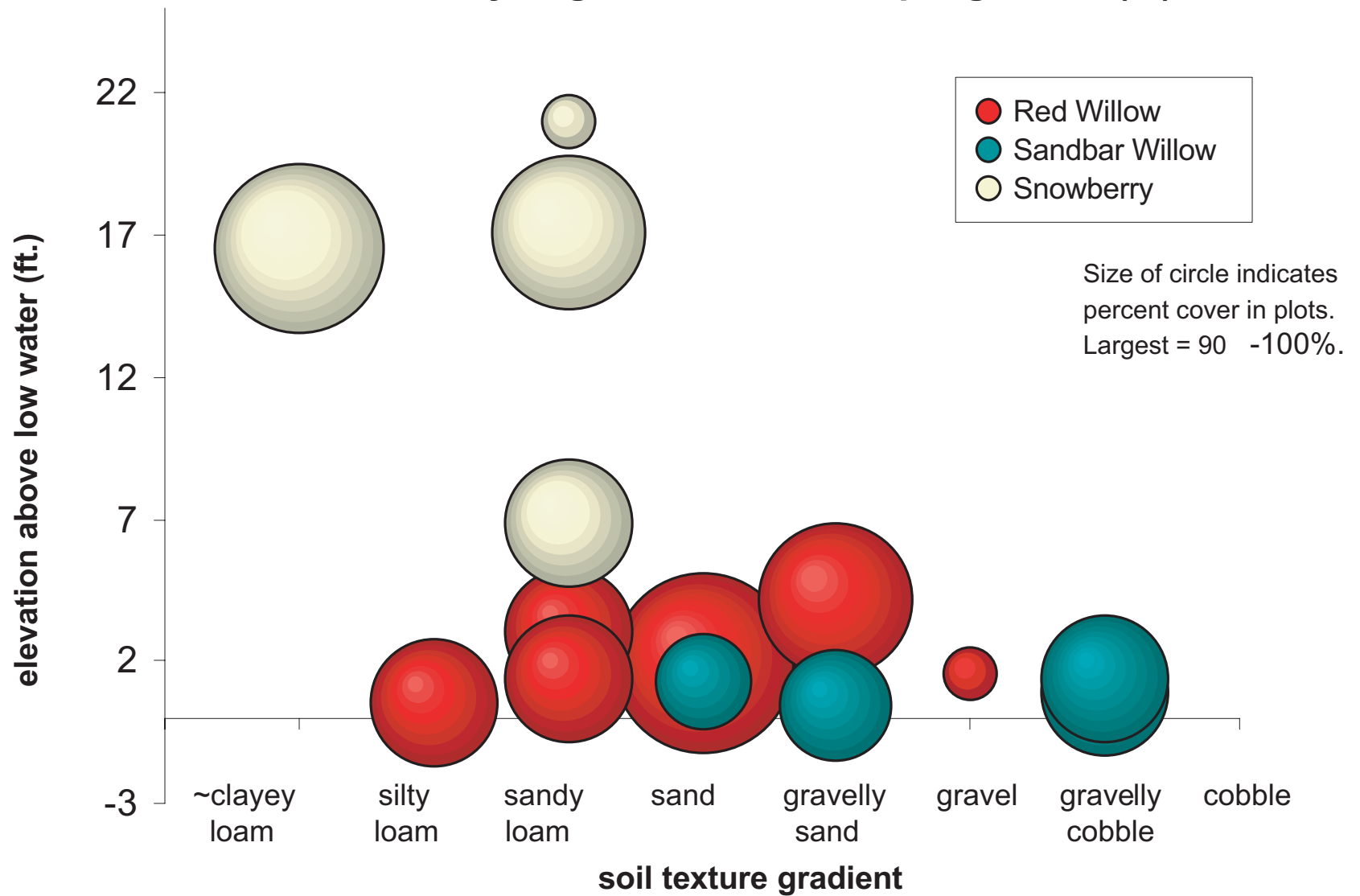
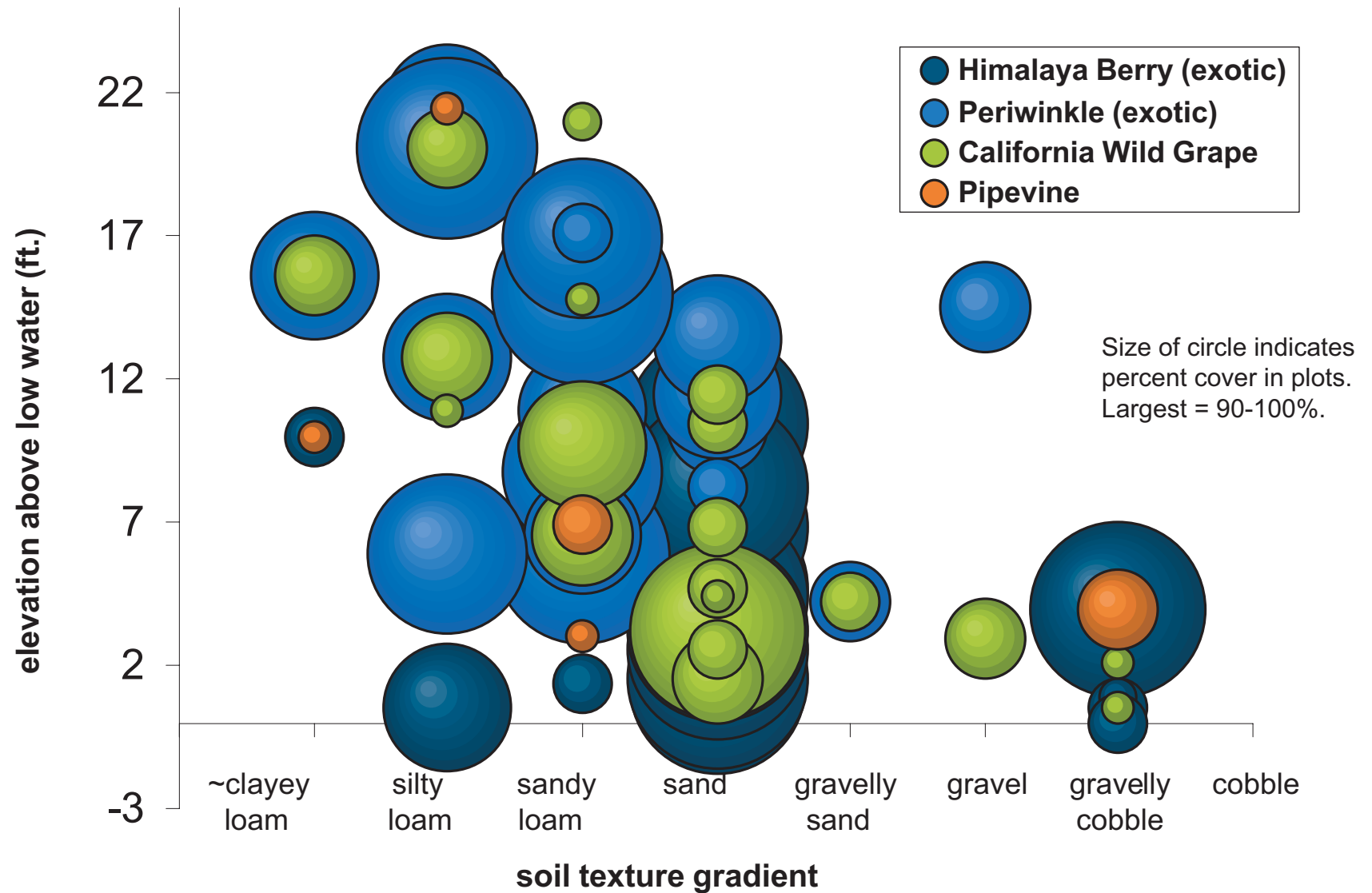


Figure 19: Relation of sapling occurrence to elevation above summer low flow and soil texture.

Understory Vegetation, Shrub/Sapling Cover (%)



Understory Vegetation, Vine Cover (%)



Understory Vegetation, Herbaceous Cover (%)

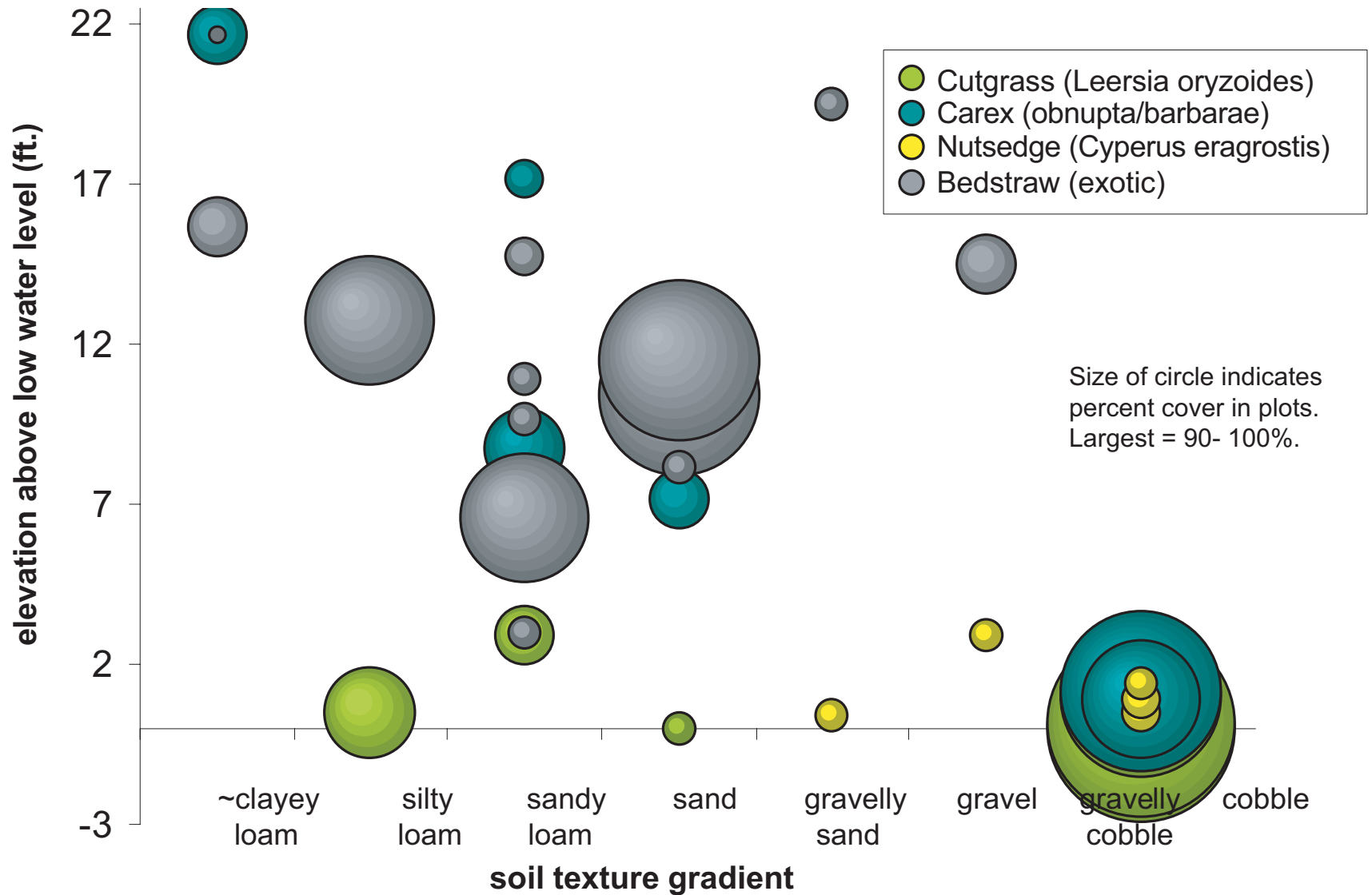
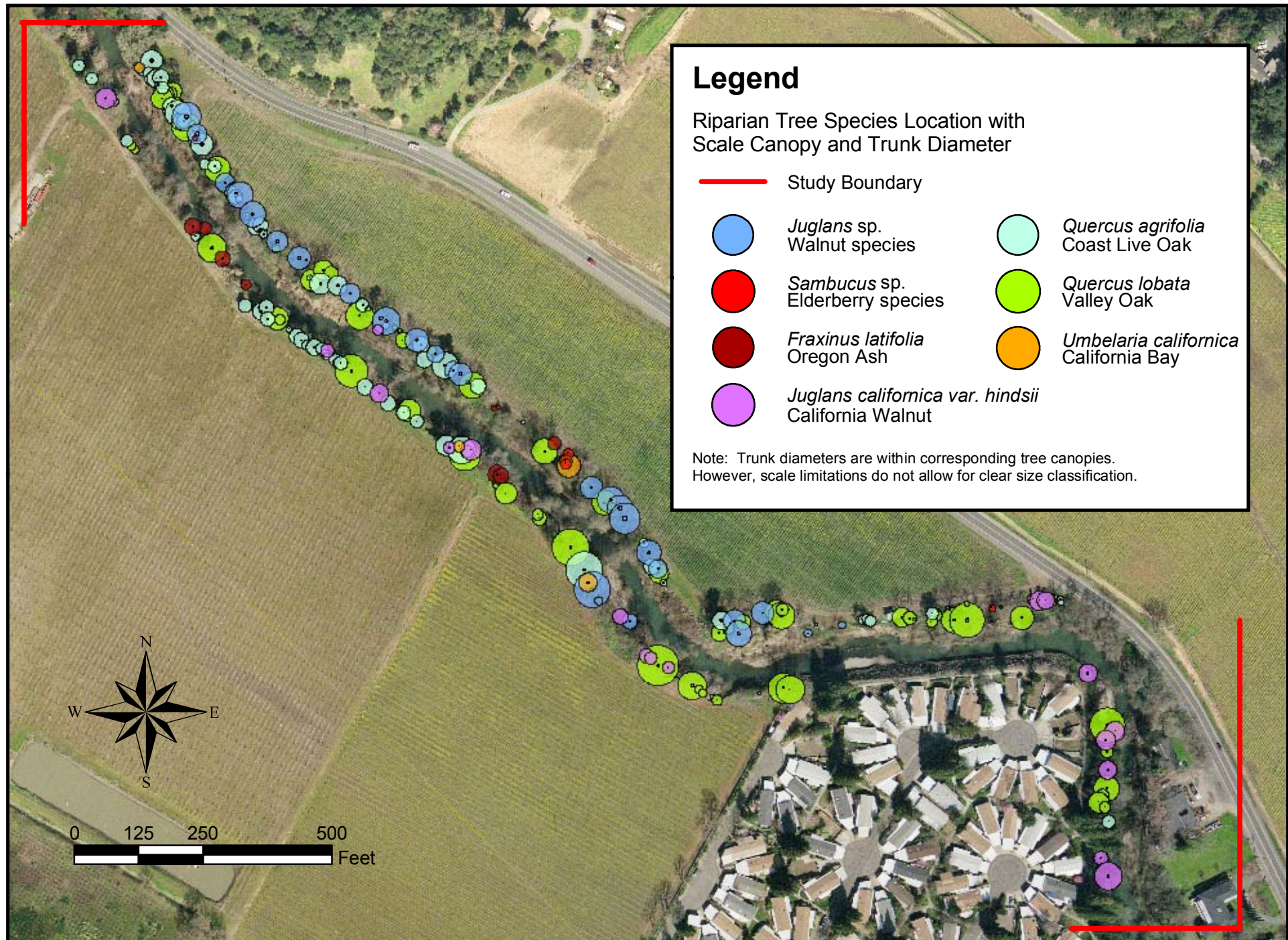
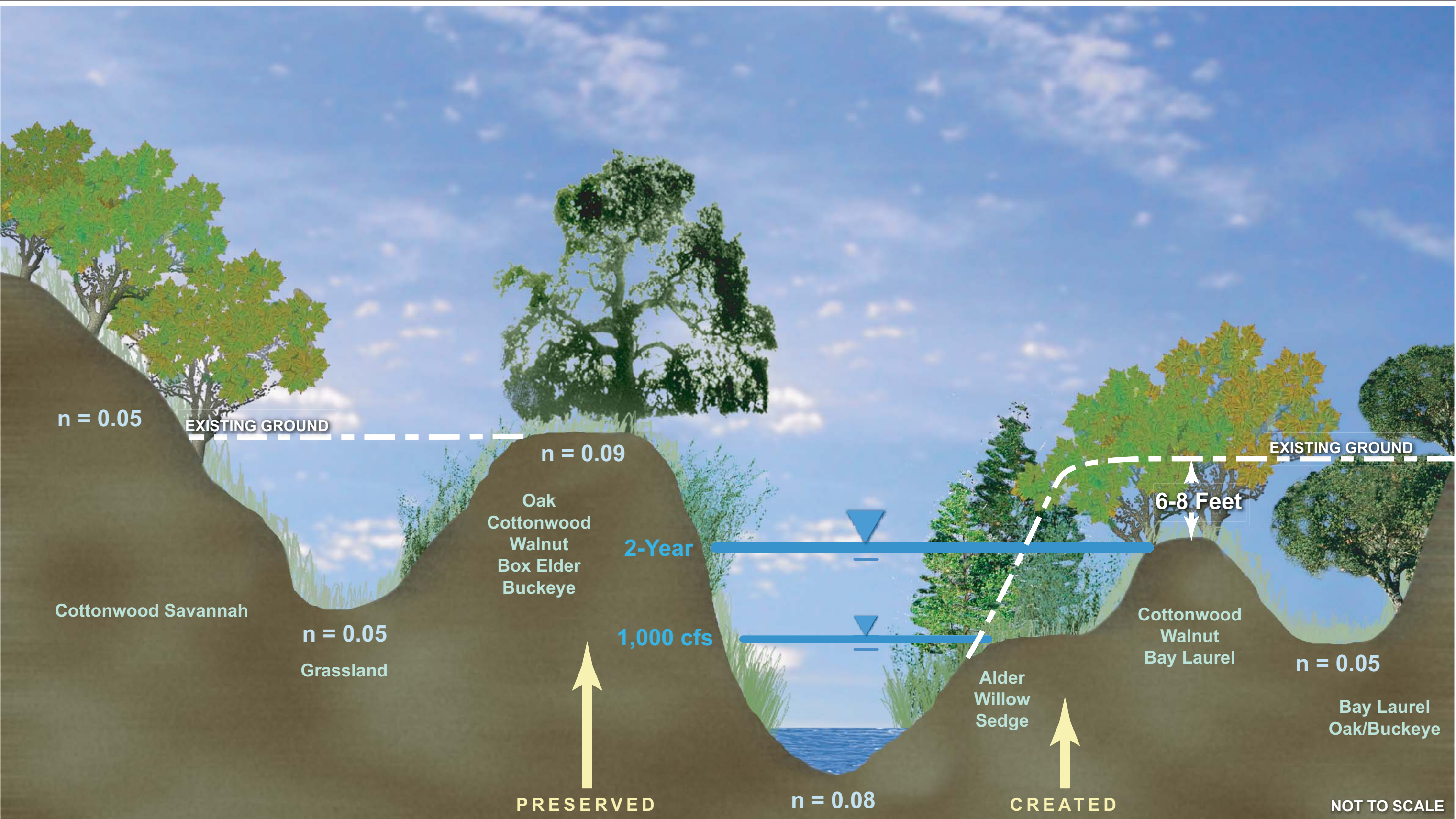


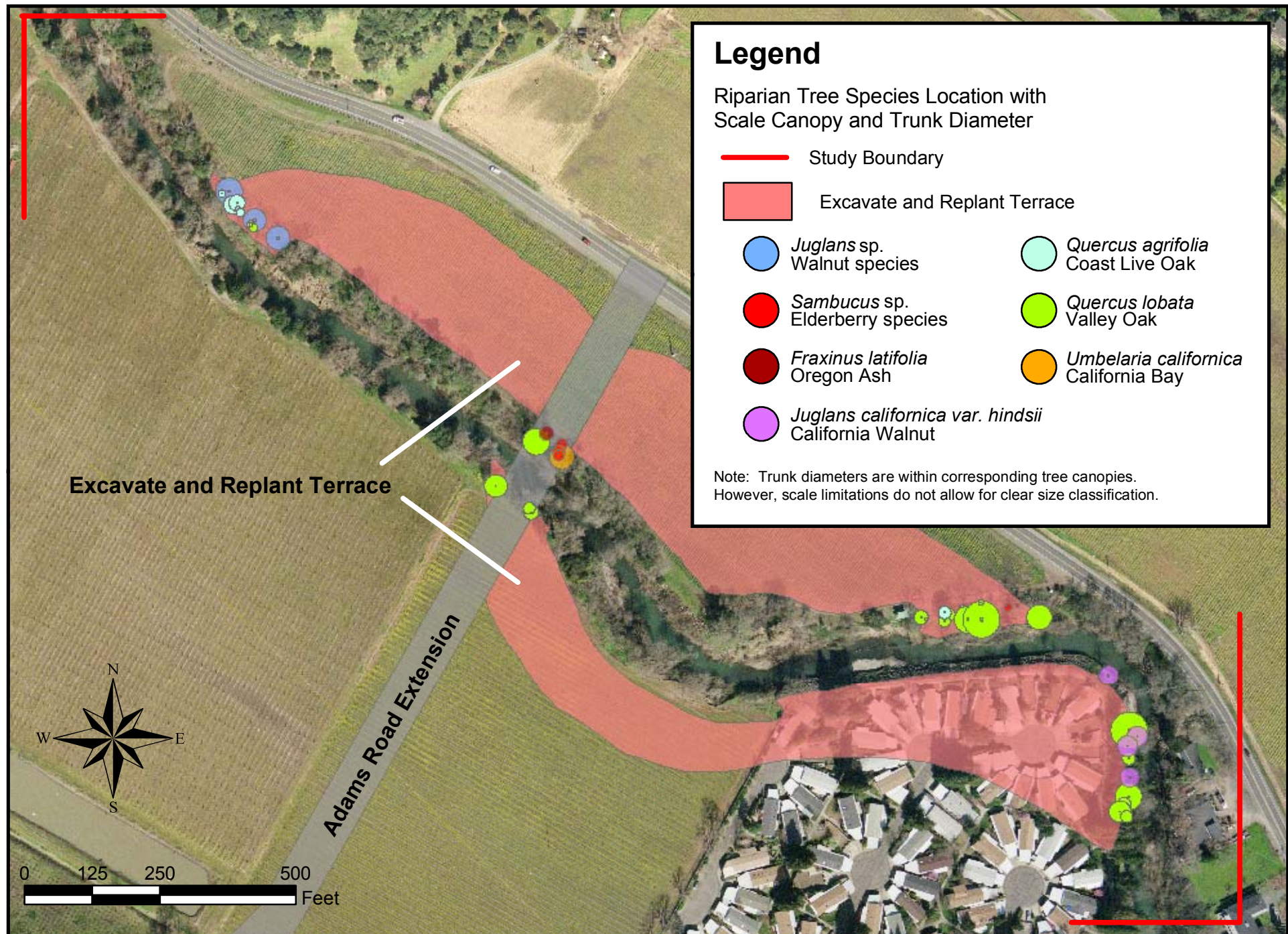
Figure 22: Relation of understory herbaceous vegetation percent cover to summer low flow and soil texture.

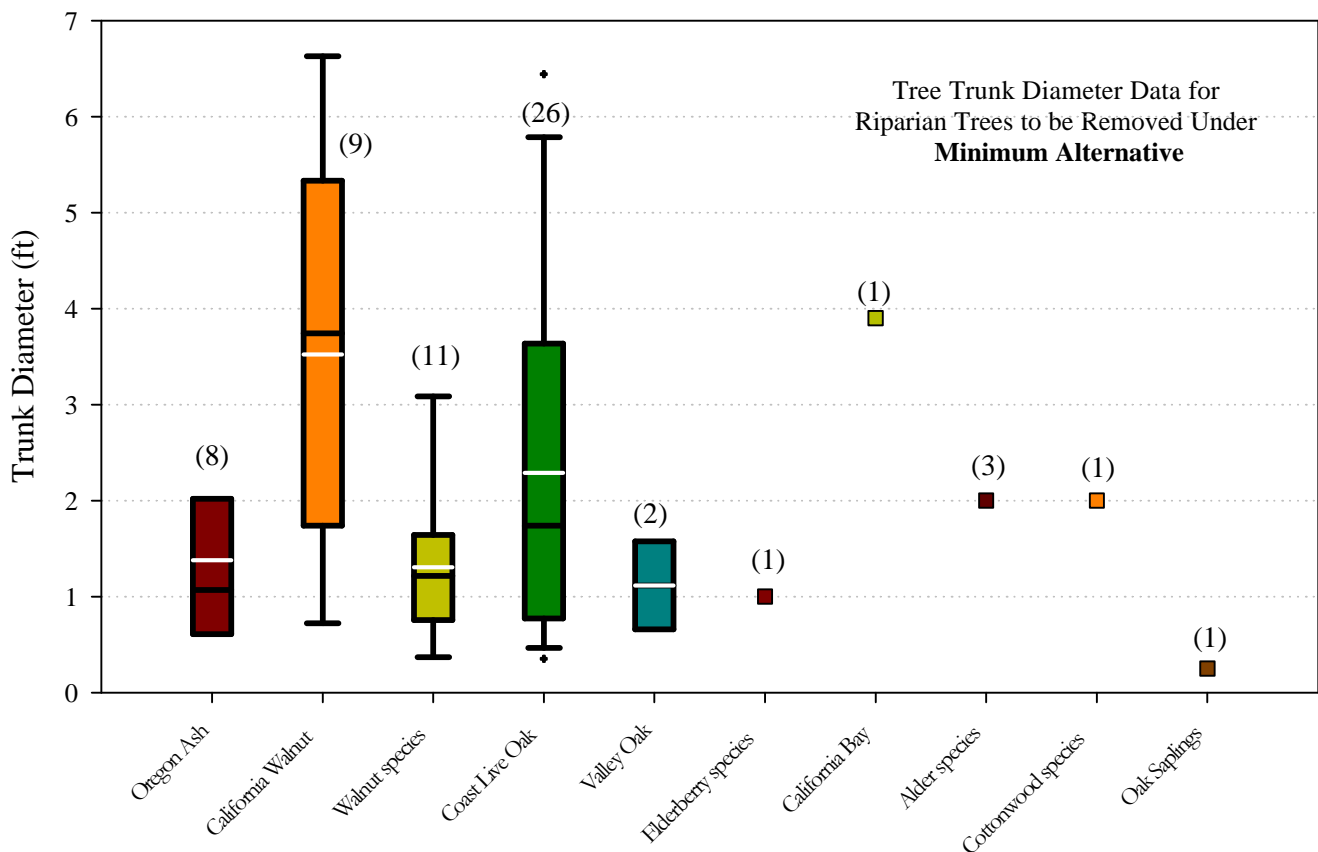
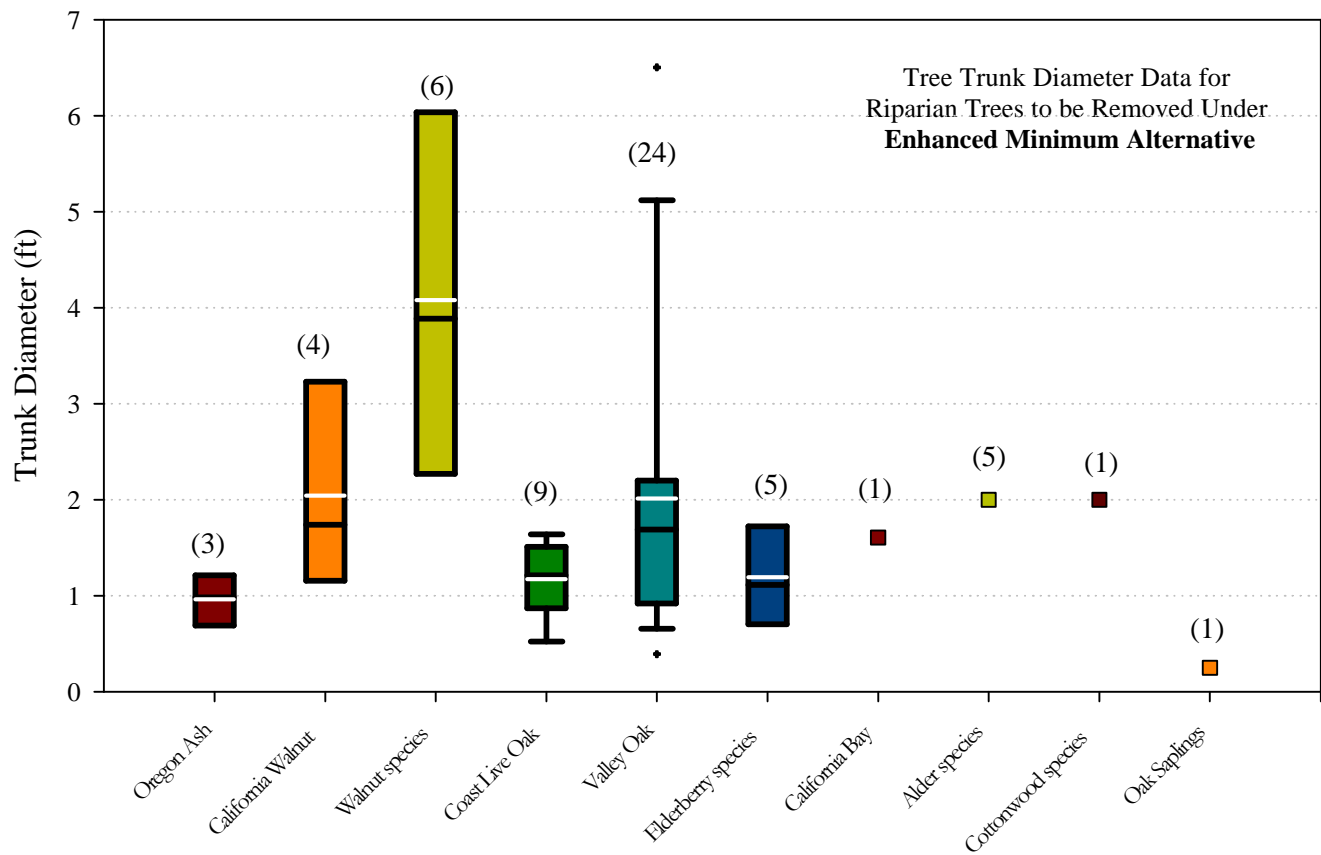




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Figure 24: Napa River near St. Helena showing conceptual depiction of post-project topography and potential vegetation communities. Light blue labels below the ground surface indicate target Mannings' hydraulic roughness values. Location of the large valley oak represents mature riparian forest to be preserved along existing banks. Areal extents for terrace areas and riparian preservation are shown in plan view in Figure 3. The south bank is expected to be excavated 6-8 feet for forested areas and more so for channel areas







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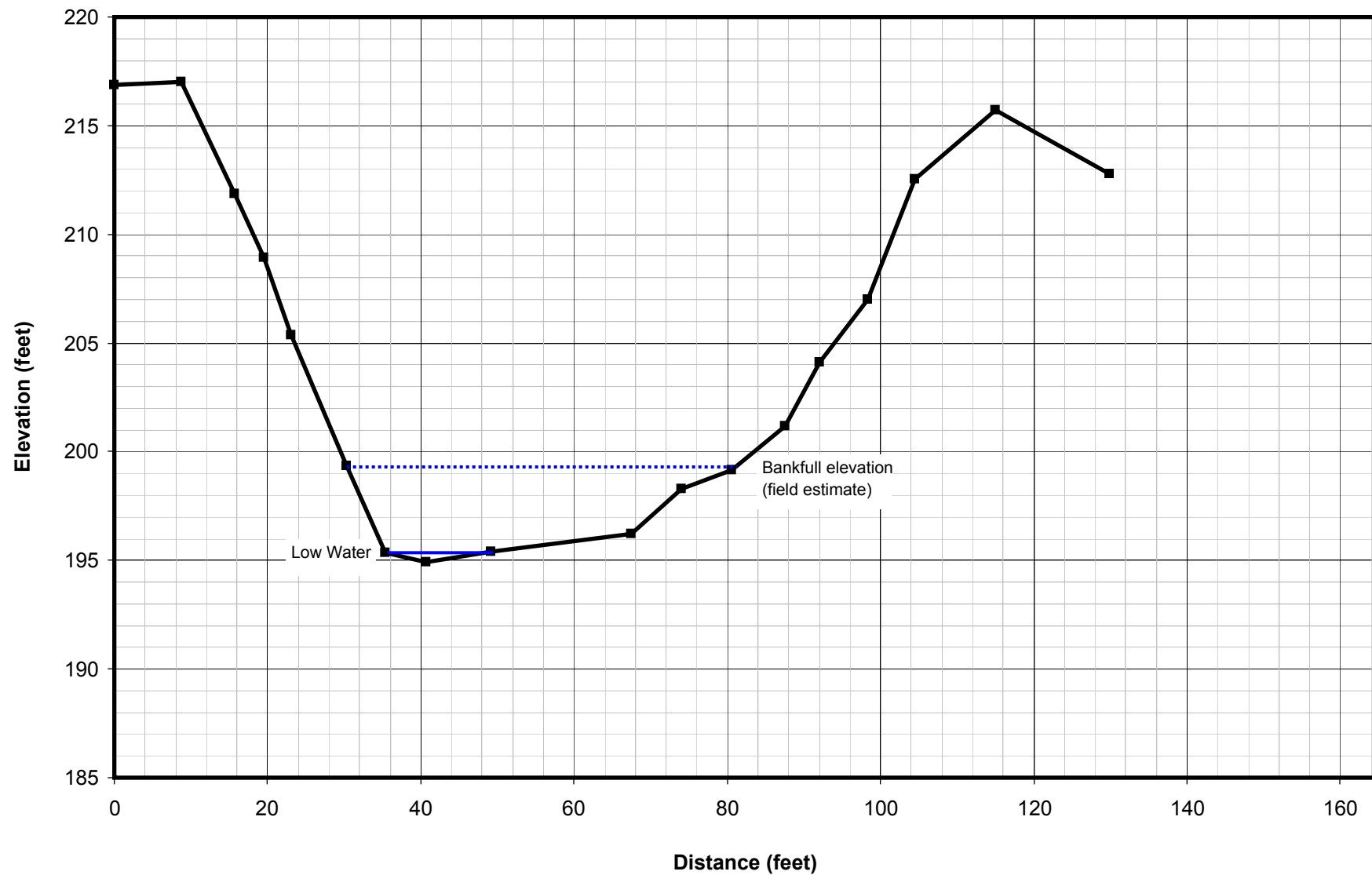
Figure 26: Exposure of soils along the north bank of the Napa River in the project reach opposite the Vineyard Valley Mobile Home Park. The proposed excavation depth will be 6-8 feet on average below the top of bank

APPENDIX A:
SH&G Cross Section Data with Bankfull Elevations

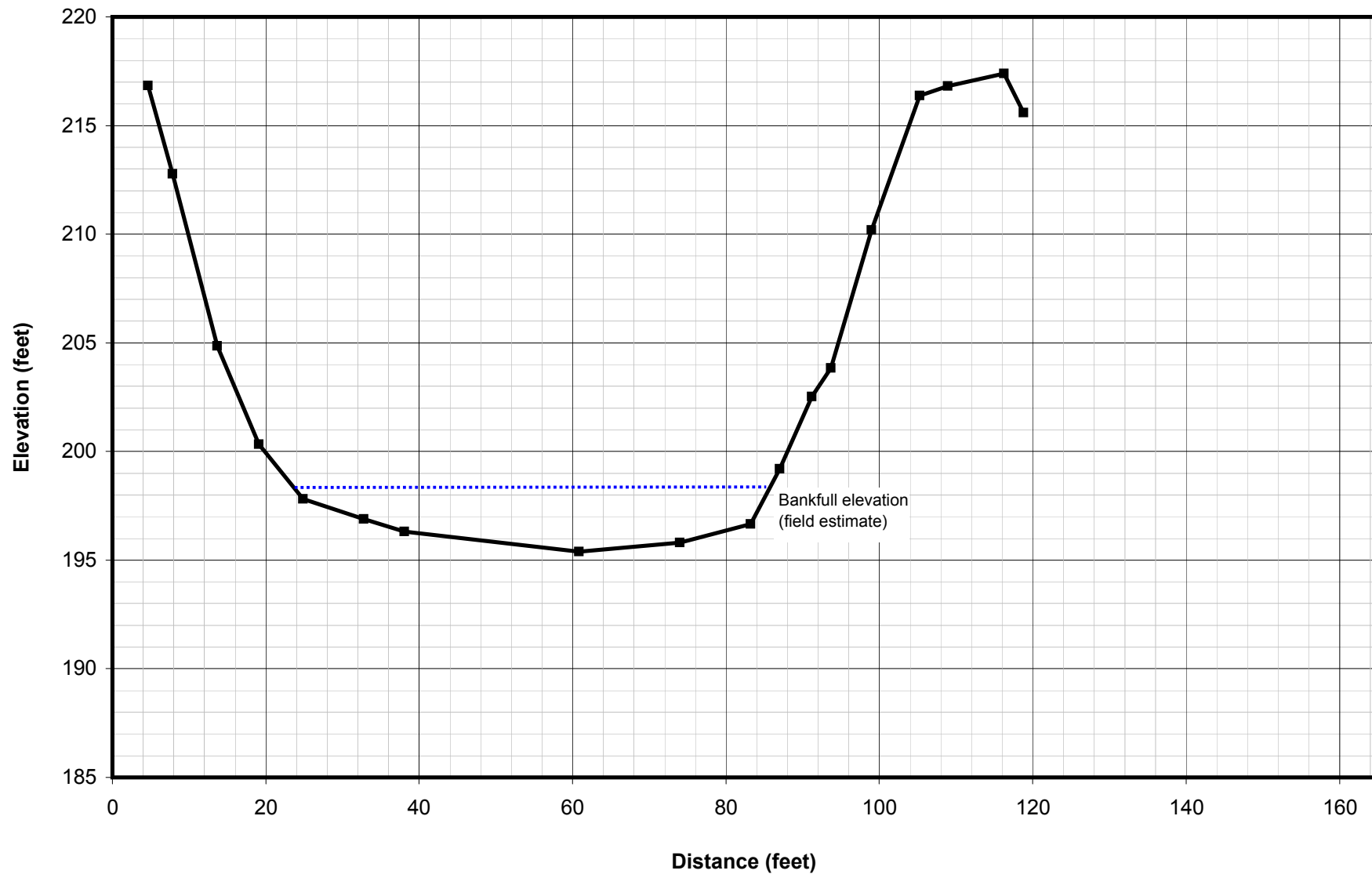
Appendix A

Napa River at St. Helena, CA

Cross-Section 1



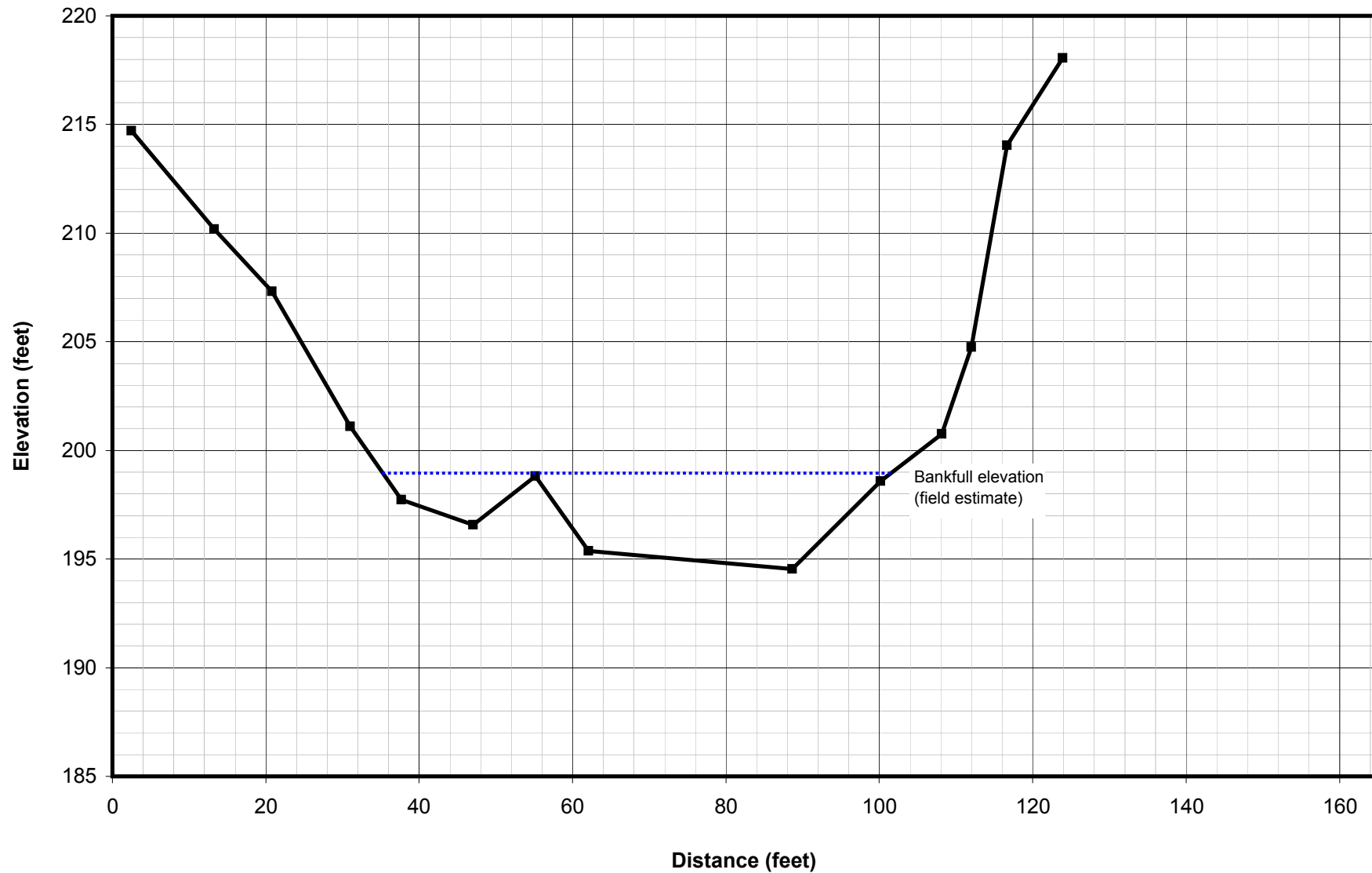
Napa River at St. Helena, CA
Cross-Section 2



Appendix A

Napa River at St. Helena, CA

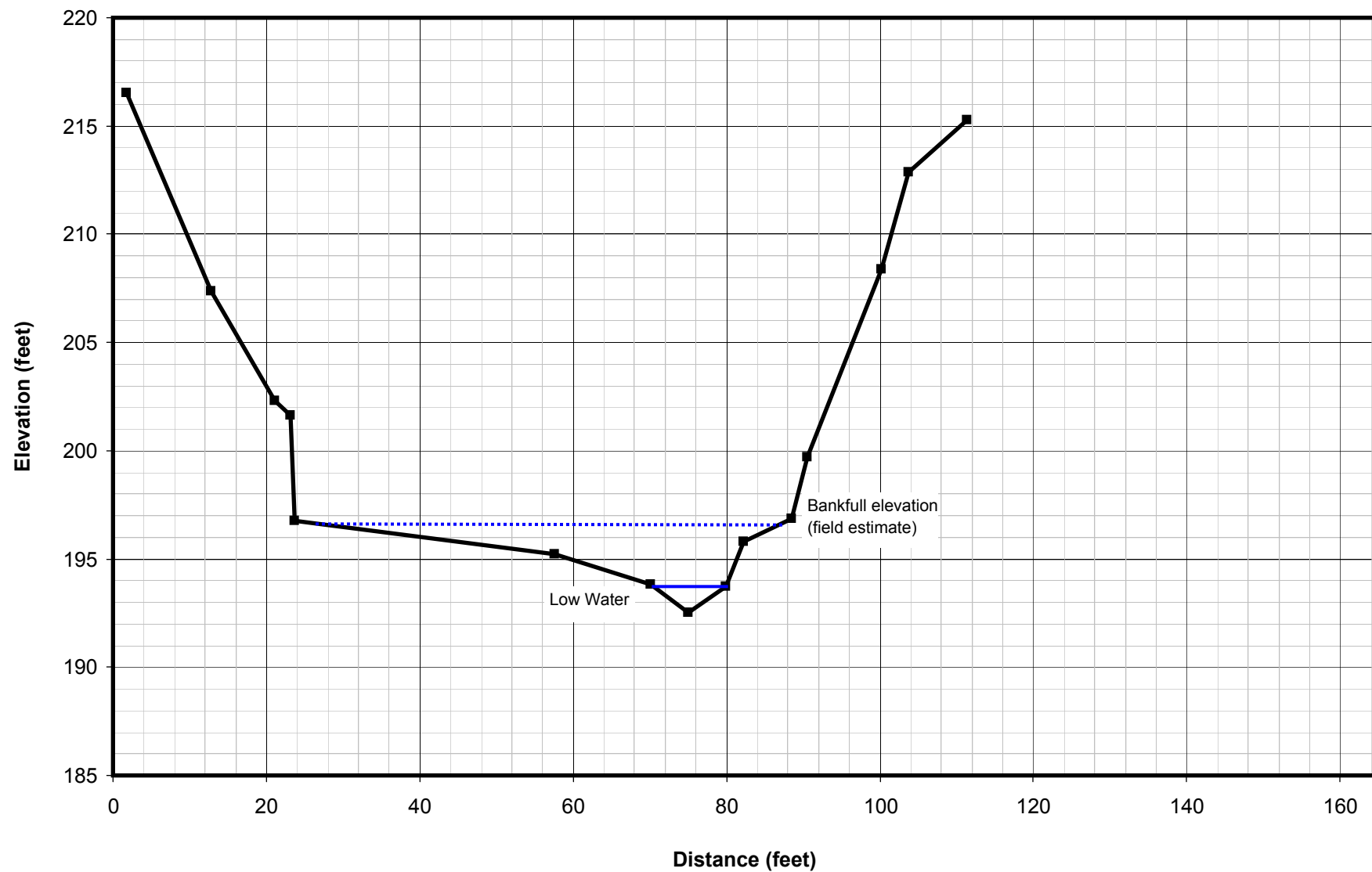
Cross-Section 3



Appendix A

Napa River at St. Helena, CA

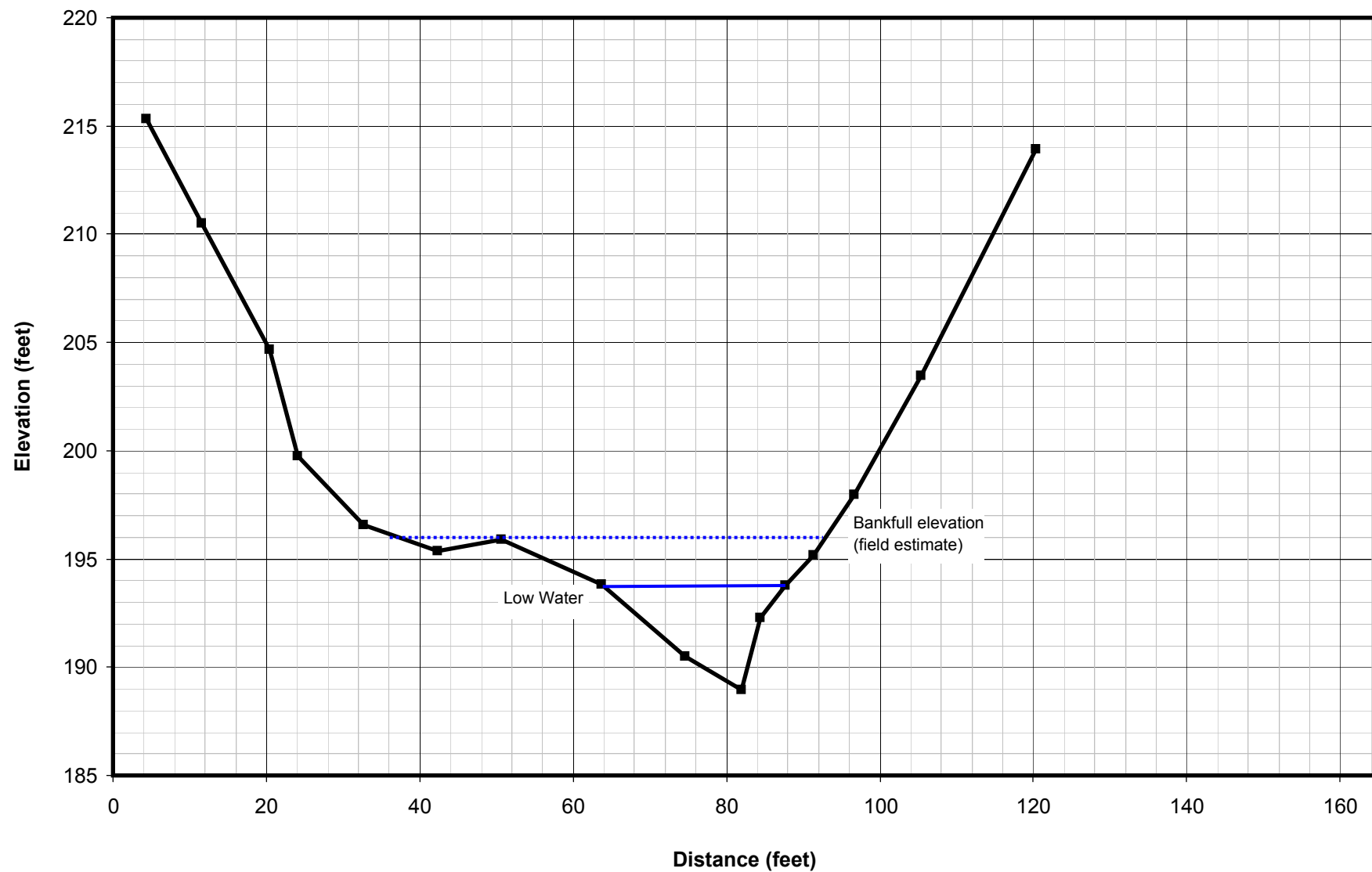
Cross-Section 4



Appendix A

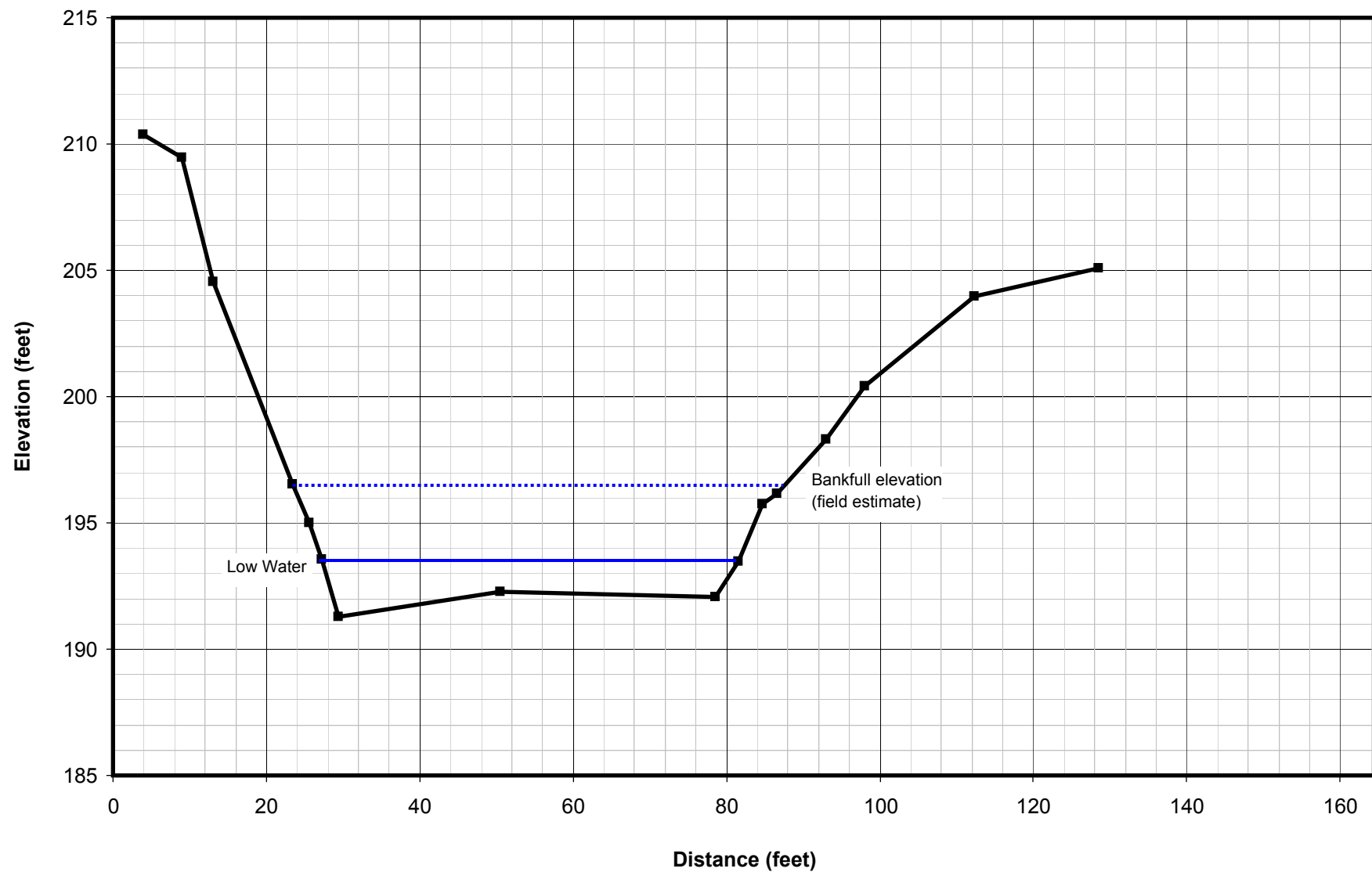
Napa River at St. Helena, CA

Cross-Section 5

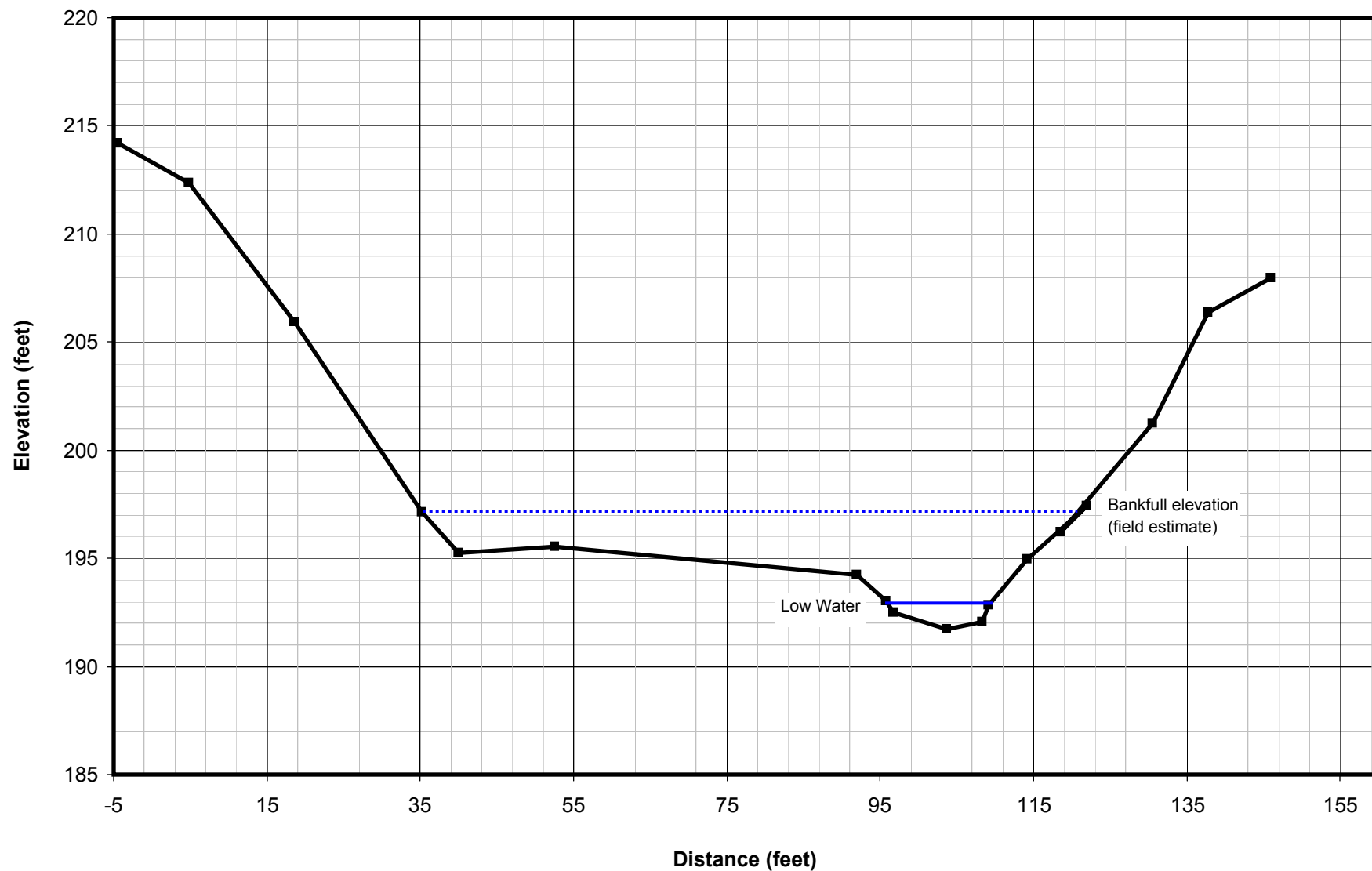


Appendix A

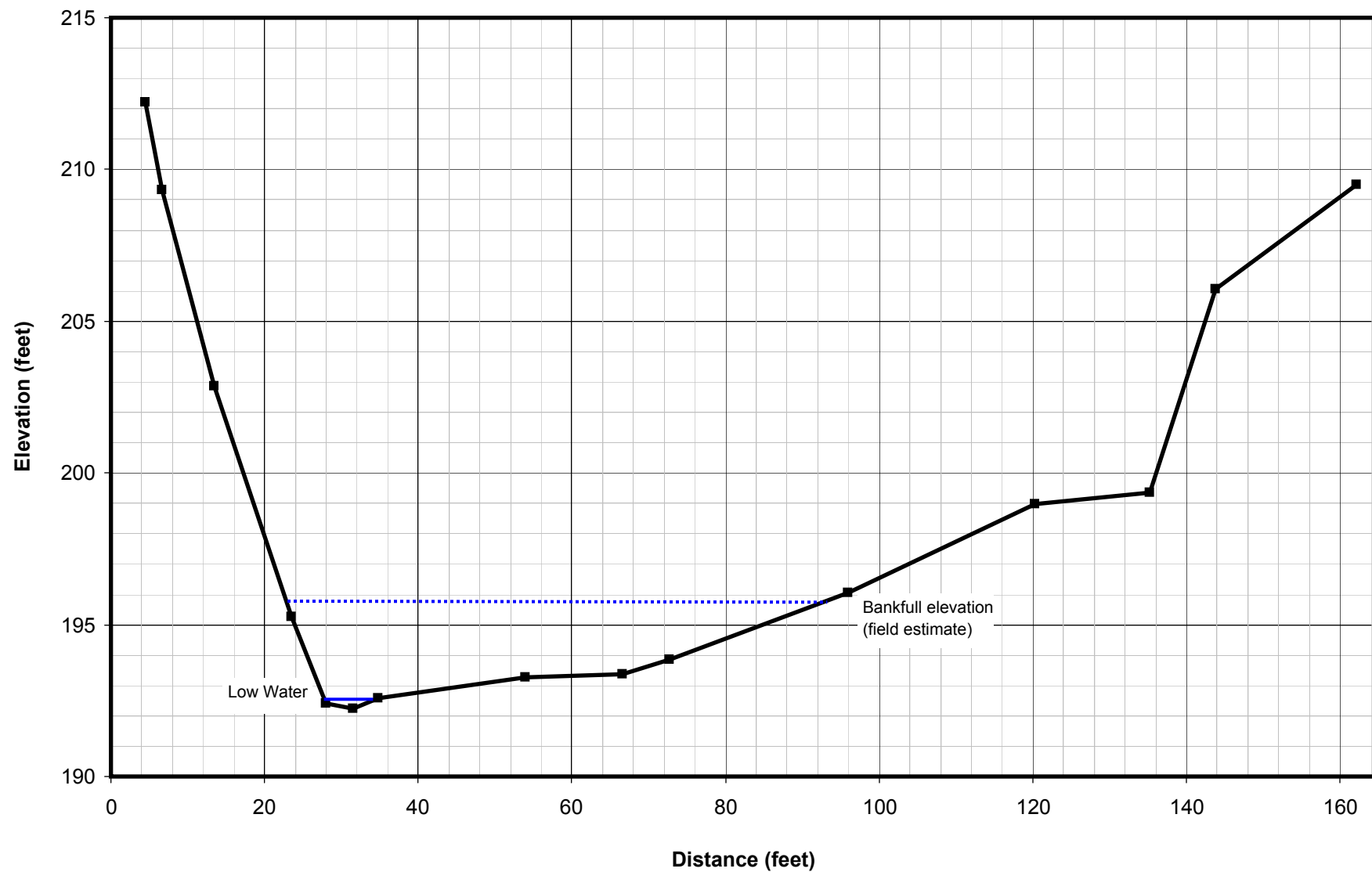
Napa River at St. Helena, CA Cross-Section 6



Napa River at St. Helena, CA
Cross-Section 7

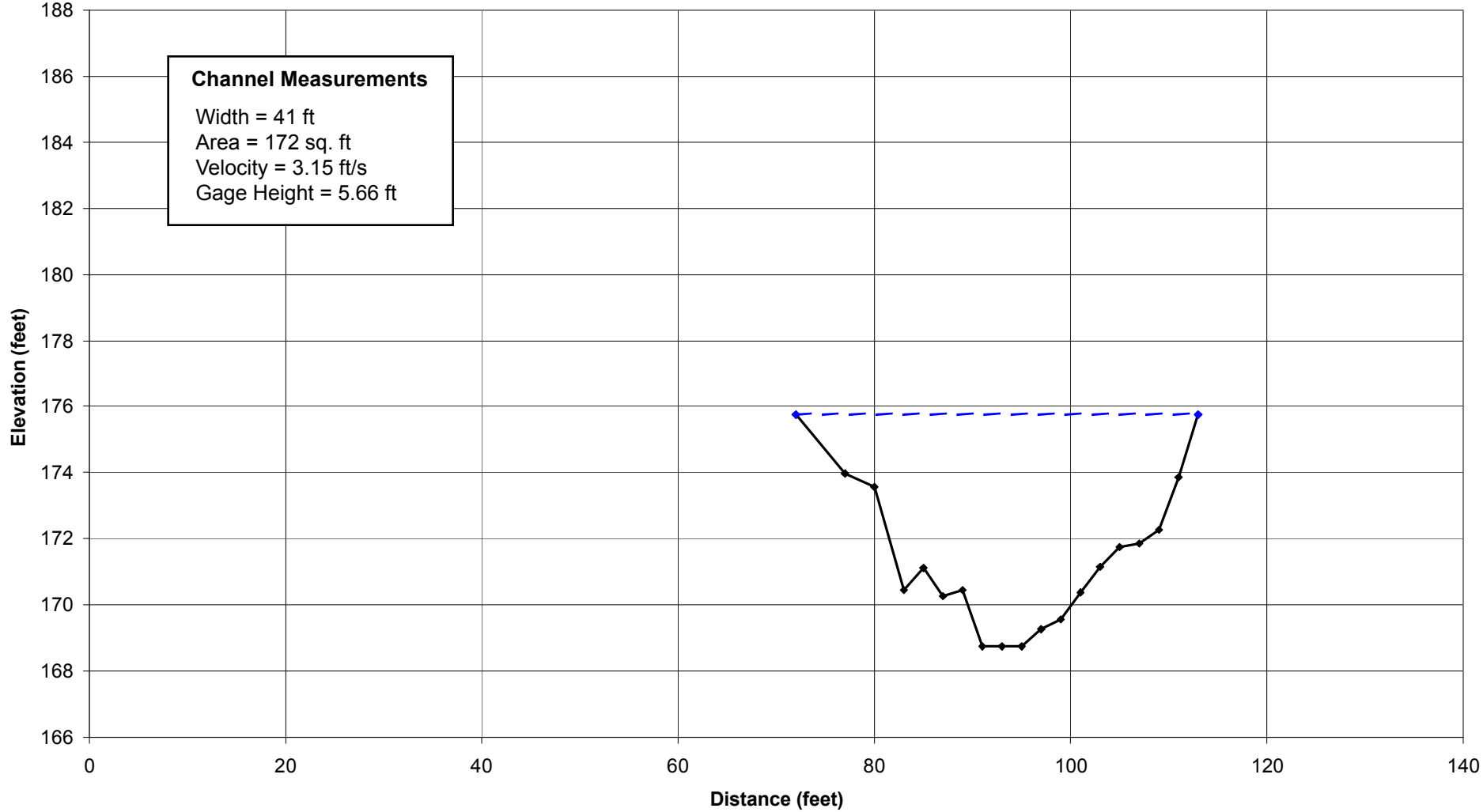


Napa River at St. Helena, CA
Cross-Section 8



APPENDIX B:
Cross Section Data from USGS Flow Measurements

CROSS-SECTION FROM USGS FLOW MEASUREMENT
Napa River near St. Helena 542 cfs
February 20, 2001

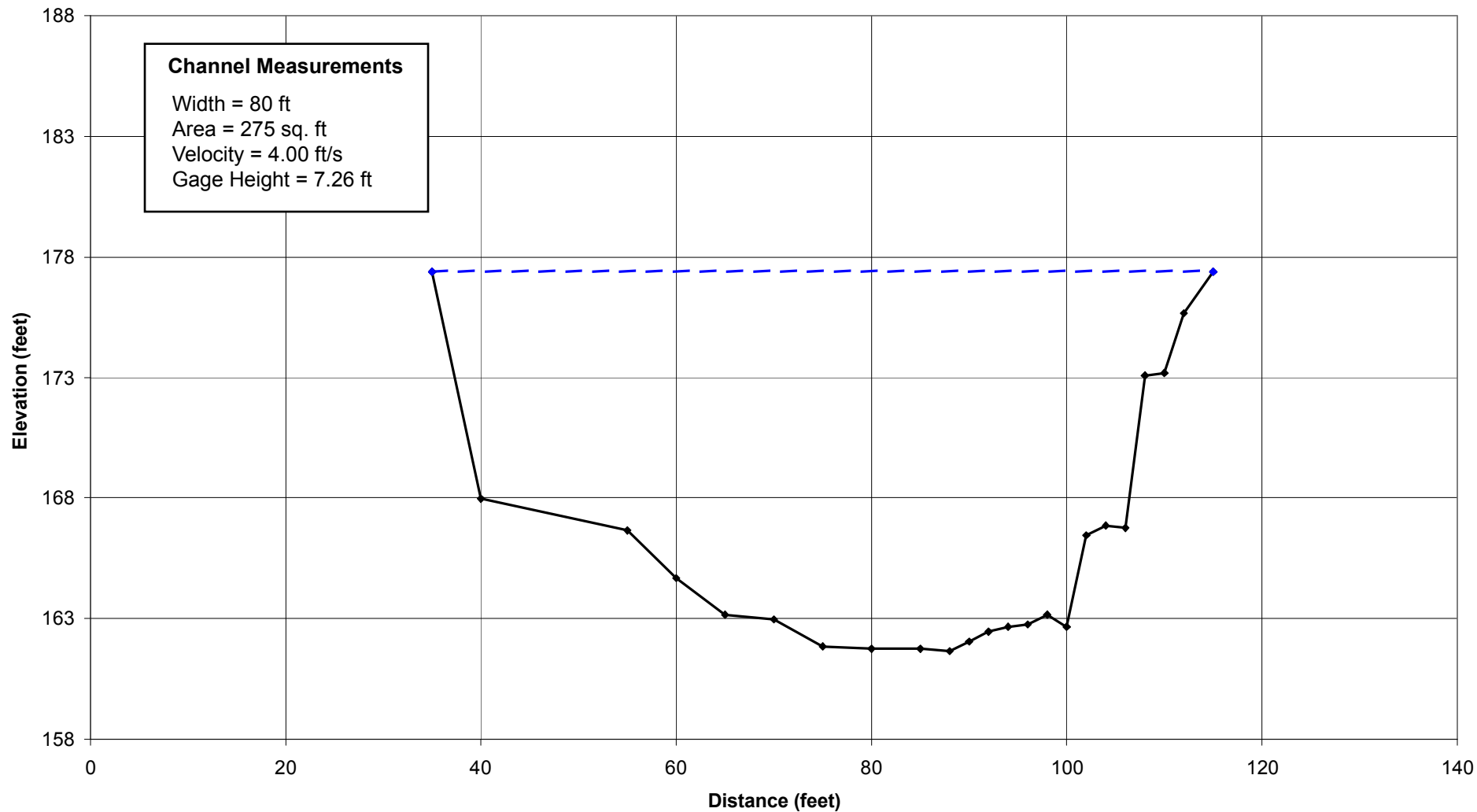


Appendix B

CROSS-SECTION FROM USGS FLOW MEASUREMENT

Napa River near St. Helena 1100 cfs

January 29, 1998



Appendix B

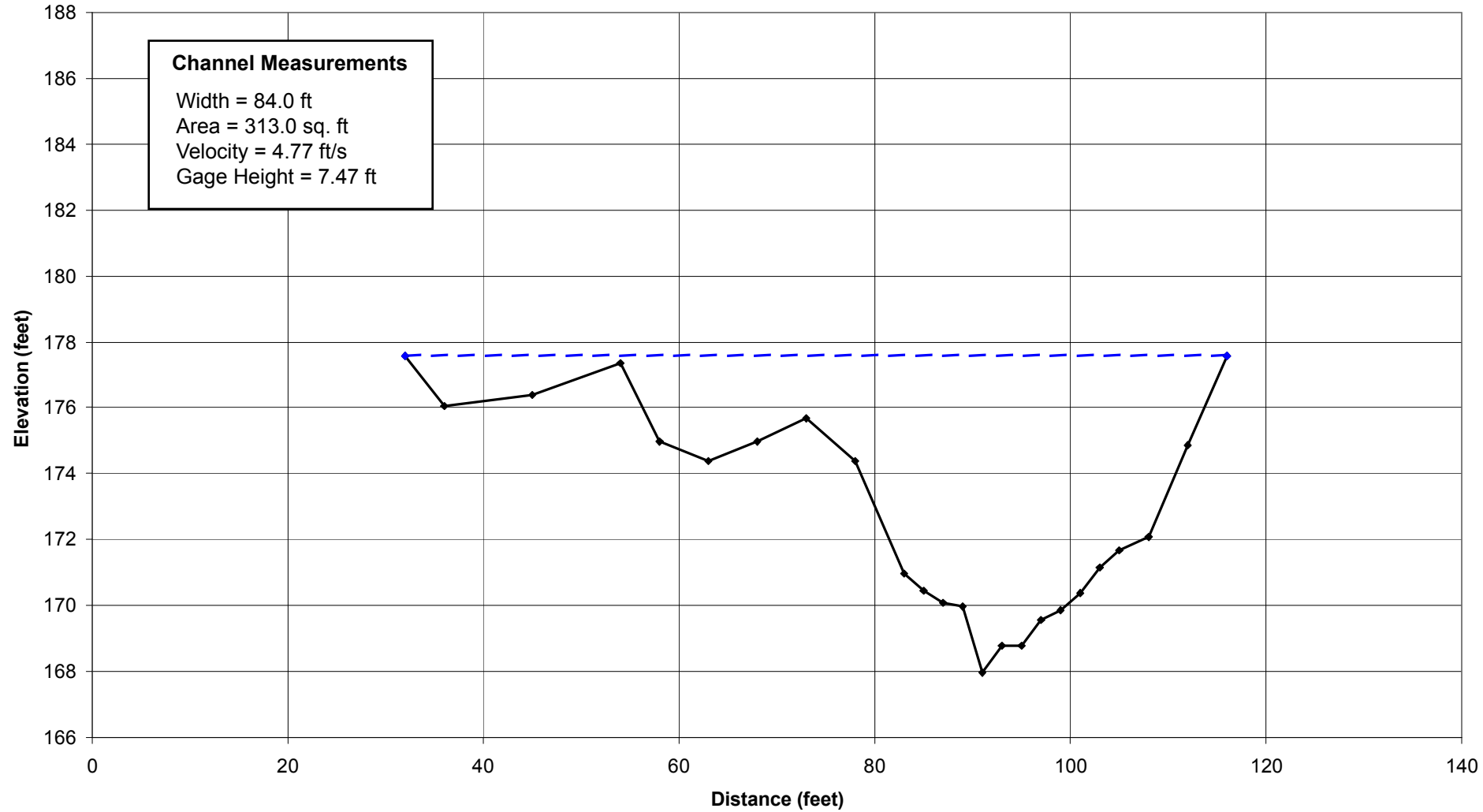
CROSS-SECTION FROM USGS FLOW MEASUREMENT

Napa River near St. Helena 1490 cfs

January 21, 1993

Channel Measurements

Width = 84.0 ft
Area = 313.0 sq. ft
Velocity = 4.77 ft/s
Gage Height = 7.47 ft

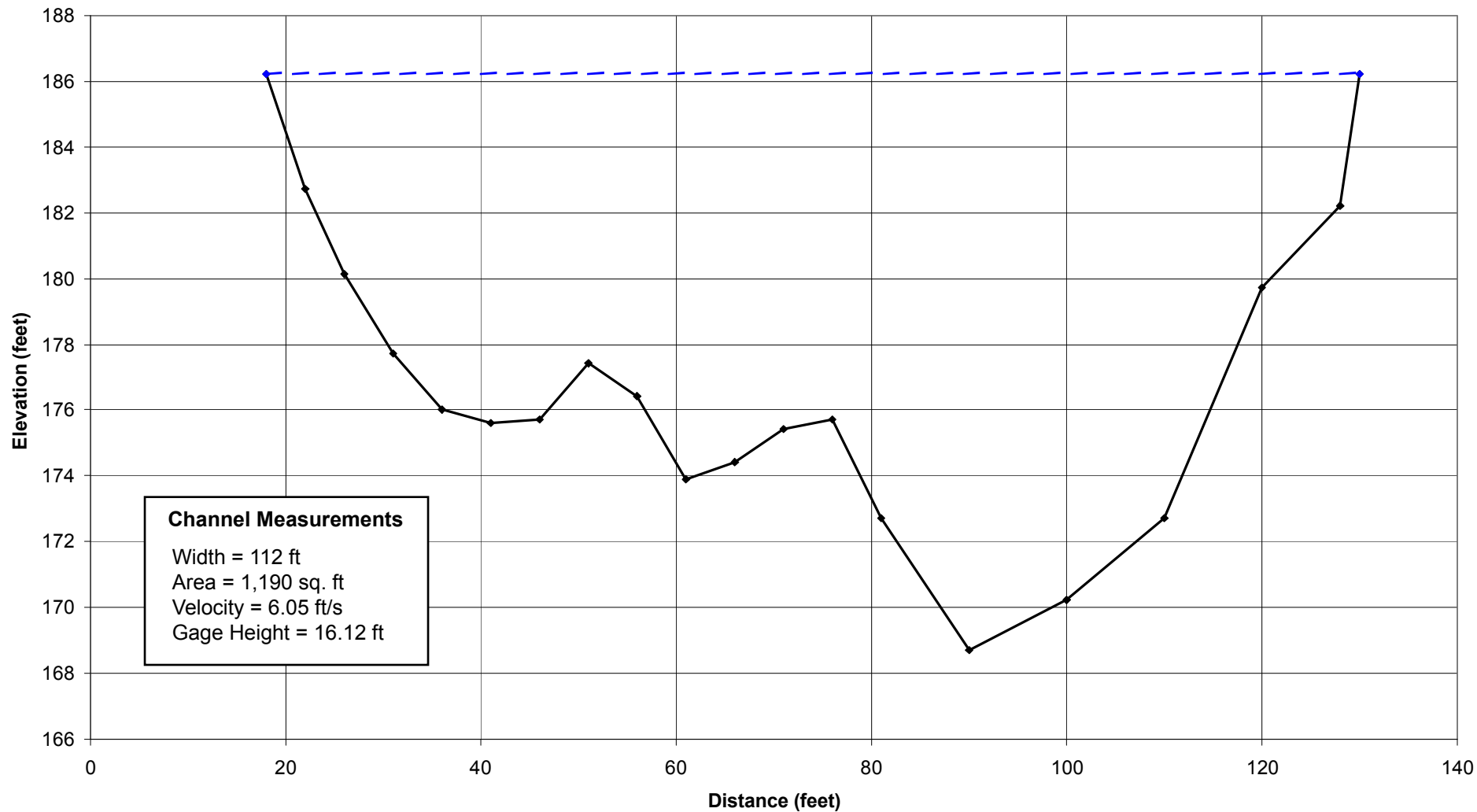


Appendix B

CROSS-SECTION FROM USGS FLOW MEASUREMENT

Napa River near St. Helena 7200 cfs

January 20, 1993



APPENDIX C:
Summary Table of Existing Trees and Trees Removed Under
Enhanced Minimum Plan

Appendix C

Riparian Tree Statistics

Species	Common Name	Number of Individual Trees/Shrub:	Average Dripline CanopyDiameter (ft)	Standard Deviator	Average Trunk Diameter (ft)	Standard Deviation
<i>Fraxinus latifolia</i>	Oregon Ash	7	28	5	1	1
<i>Juglans californica</i> var. <i>hindsii</i>	California Walnut	21	31	9	1	1
<i>Juglans</i> species	Walnut species	30	41	15	4	2
<i>Quercus agrifolia</i>	Coast Live Oak	83	25	12	2	1
<i>Quercus lobata</i>	Valley Oak	74	32	19	2	2
<i>Sambucus</i> species	Elderberry Species	9	13	8	1	0
<i>Umbelaria californica</i>	California Bay	4	31	12	2	1

Riparian Trees to be Removed Under Enhanced Minimum Alternative

Area	Species	Common Name	Number of Individual Trees/Shrub:	Average Dripline Canopy Diameter (ft)	Standard Deviator	Average Trunk Diameter (ft)	Standard Deviation
Northern Floodplain Inlet	<i>Alnus</i> species	Alder species	7	20	n/a	2	n/a
	<i>Arundo donax</i>	Giant Reed	1 stand	n/a	n/a	n/a	n/a
	<i>Juglans</i> species	Walnut species	7	39	19	4	2
	<i>Quercus agrifolia</i>	Coast Live Oak	8	21	9	1	0
	<i>Quercus lobata</i>	Valley Oak	2	15	1	4	4
	<i>Salix</i> species	Willow species	5	15	n/a	2	n/a
	<i>Sambucus species</i>	Elderberry species	1	10	n/a	1	n/a
Northern Floodplain Outlet	<i>Alnus</i> species	Alder species	42	20	n/a	2	n/a
	<i>Arundo donax</i>	Giant Reed	2 stands	n/a	n/a	n/a	n/a
	<i>Quercus agrifolia</i>	Coast Live Oak	1	24	n/a	2	n/a
	<i>Quercus lobata</i>	Valley Oak	9	30	21	2	2
	<i>Salix</i> species	Willow species		15	n/a	2	n/a
	<i>Sambucus species</i>	Elderberry species	2	10	6	1	1
Southern Foodplain Inlet	<i>Alnus</i> species	Alder species	9	20	n/a	2	n/a
	<i>Fraxinus latifolia</i>	Oregon Ash	3	33	4	1	0.2
	<i>Juglans</i> species	Walnut species	1	15	n/a	2	n/a
	<i>Quercus lobata</i>	Valley Oak	4	26	13	1	0.4
	<i>Salix</i> species	Willow species	7	15	n/a	2	n/a
Southern Foodplain Outlet/Reach Boundary	<i>Alnus</i> species	Alder species	2	20	n/a	2	n/a
	<i>Arundo donax</i>	Giant Reed	1 stand	n/a	n/a	n/a	n/a
	<i>Junglans californica</i> var. <i>hindsii</i>	California Walnut	5	37	1.15	2	1
	<i>Populus</i> species	Cottonwood species	1	20	n/a	2	n/a
	<i>Quercus lobata</i>	Valley Oak	8	43	18	2	1
	<i>Quercus</i> species	Oak Species	n/a	2	n/a	0	n/a
	<i>Salix</i> species	Willow species	n/a	15	n/a	2	n/a
Adams Road Extension/ Bridge (*=overlaps with Western Floodplain Inlet)	<i>Aesculus</i> species	Buckeye species	2	n/a	n/a	n/a	n/a
	<i>Alnus</i> species	Alder species	4	20	n/a	2	n/a
	<i>Fraxinus latifolia</i>	Oregon Ash	1	26	n/a	1	n/a
	<i>Quercus lobata</i>	Valley Oak	1	50	n/a	2	n/a
	<i>Sambucus</i> species	Elderberry species	3	21	2	1	1
	<i>Umbelaria californica</i>	California Bay	1	46	n/a	2	n/a
	<i>Quercus lobata</i> *	Valley Oak	3	31	10	1	0.2
	<i>Salix species</i>	Willow species	4	15	n/a	2	n/a

Appendix C (cont.)

Riparian Trees to be Removed Under Minimum Plan

Area	Species	Common Name	Number of Individual Trees/ Shrubs	Average Dripline Canopy Diameter (ft)	Standard Deviation	Average Trunk Diameter (in)	Standard Deviation
Northern Floodplain Inlet	<i>Alnus</i> species	Alder species	7	20	n/a	2	n/a
	<i>Arundo donax</i>	Giant Reed	1 stand	n/a	n/a	n/a	n/a
	<i>Juglans</i> species	Walnut species	7	39	19	4	1.88
	<i>Quercus agrifolia</i>	Coast Live Oak	8	21	9	1	0.36
	<i>Quercus lobata</i>	Valley Oak	2	15	1	4	4.11
	<i>Salix</i> species	Willow species	5	15	n/a	2	n/a
	<i>Sambucus species</i>	Elderberry species	1	10	n/a	1	n/a
Northern Floodplain Outlet	<i>Alnus</i> species	Alder species	42	20	n/a	2	n/a
	<i>Arundo donax</i>	Giant Reed	2 stands	n/a	n/a	n/a	n/a
	<i>Quercus agrifolia</i>	Coast Live Oak	1	24	n/a	2	n/a
	<i>Quercus lobata</i>	Valley Oak	9	30	21	2	1.80
	<i>Salix</i> species	Willow species	7	15	n/a	2	n/a
	<i>Sambucus</i> species	Elderberry species	2	10	6	1	0.65
Southern Floodplain Inlet	<i>Juglans californica</i> var. <i>hindsii</i>	California Walnut	4	27	3	1	0.20
	<i>Juglans</i> species	Walnut species	3	39	28	2	2.15
	<i>Quercus agrifolia</i>	Coast Live Oak	2	39	47	2	2.20
	<i>Quercus lobata</i>	Valley Oak	7	39	29	2	2.46
	<i>Umbelaria californica</i>	California Bay	1	4	n/a	36	n/a
Southern Floodplain Outlet	<i>Alnus</i> species	Alder species	2	20	n/a	2	n/a
	<i>Arundo donax</i>	Giant Reed	1 stand	n/a	n/a	n/a	n/a
	<i>Juglans californica</i> var. <i>hindsii</i>	California Walnut	5	37	1	2	1.13
	<i>Populus</i> species	Cottonwood species	1	20	n/a	2	n/a
	<i>Quercus lobata</i>	Valley Oak	8	43	18.1	2	0.87
	<i>Quercus</i> species	Oak Species	n/a	2	n/a	0	n/a
	<i>Salix</i> species	Willow species	n/a	15	n/a	2	n/a